AGRICULTURAL DRAINAGE:

A RETROSPECT OF FORTY YEARS' EXPERIENCES.

I. Land Drainage and Drainage Systems.

II. The Progress of Under-Drainage.

III. The Effect of Under-Drainage on Rivers and Arterial Channels.

IV. The Past, the Present, and the Future of Under-Drainage.

V. Borrowed Capital applied to Land Drainage.

BY

J. BAILEY DENTON, C.E., F.G.S., &c.,

UPWARDS OF THIRTY YEARS PRINCIPAL ENGINEER TO THE GENERAL LAND DRAINAGE AND IMPROVEMENT COMPANY;

Author of "The Farm Homesteads of England"; Lectures given before the School of Military Engineering, Chatham, on "Sanitary Engineering"; "The Agricultural Labourer"; Technical Teaching in Rural Elementary Schools, &c., &c.

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THESE PAGES

Are submitted by the Author, with great respect, to the Land Commissioners of England,

FOR THEIR CONSIDERATION.

PREFACE.

THE following treatise on Under-drainage in England and Wales consists of extracts from essays published, and from lectures delivered on the subject at different times during the last forty years, interspersed with passages from other kindred essays and papers of various dates; the object being to place before the reader such differences and coincidences as will enable him to trace from the commencement, the progress of works, and the influence of public opinion on the subject. This mixture of written essays with spoken addresses will explain the various personal and impersonal modes of expression.

Having given this small work the title of "A Retrospect of Forty Years' Experiences" the author desires to justify the term by explaining that so far back as 1842 he acted with the late Mr. James Smith, of Deanston—the pioneer in land drainage—and Mr. Charnock, of Wakefield, and other earnest agriculturists, in founding the first association for the drainage of estates with collective capital, and, as stated in the 5th division of this treatise, he then had the opportunity, with the co-operation of Mr. Philip Pusey, M.P., and Mr. Bellenden Ker, the eminent counsel, and the support of the late Duke of Richmond, of obtaining an extension of existing parliamentary powers in the shape of the special provision giving to improvement loans priority over existing mortgages—an advantage which is considered to have done more to advance agriculture than any other step distinguishing the progress of the last forty years. The author, having taken the initiative in obtaining this valuable concession, may be pardoned the satisfaction he feels in the fact that with probably more than a million and a half acres drained with borrowed capital, as much as half the money borrowed for the purpose has already been repaid by instalments, without in any way injuriously affecting the interests of the existing mortgagees.

Remembering the great difficulty experienced in overcoming the objections of the law officers of the Crown to the proposal when first

brought before the House of Commons, it is extremely gratifying to know that at this moment, after probably ten millions of borrowed money have been expended and charged on estates for improvements of different kinds, there has been no reason to regret the concession made by Parliament, although it was declared by the highest legal authorities at the time it was introduced that it went beyond the limits of national prudence.

DIVISION I.

LAND DRAINAGE

AND

DRAINAGE SYSTEMS.

Reprint of portions of a paper read before the London Central Farmers' Club, on the 5th of December, 1854, entitled "The Results arrived at from the several Systems of Drainage in practice during the last few years."

ALTHOUGH perhaps no subject connected with agriculture has been more frequently discussed of late years than the drainage of land, yet it is quite certain that nothing could tend more to the general benefit of the country than a clear exposition of the experience gained since the passing of the Public Moneys Drainage Act, 1846, during which time so much has been done towards the establishment of principles to guide future operations. Original paper 1854.

I have been connected with drainage sufficiently long to be a witness of the complete overthrow of several opinions which have prevailed for a time; and I am bound to acknowledge that every day's experience, while strengthening some views and modifying others, is proving to me that I have been as frequently wrong as the rest of my brethren, and that after all the intelligence and outlay that have been brought to bear on the subject, there is yet much to learn ere it can be said that we are perfect in the art of draining. It is plain, therefore, that we ought still to receive with respect opinions based on experience, even though those opinions may differ from our own.

Reverting to the year 1846, in which the first Act, authorising "*the advance of public money to promote the improvement of land by works of drainage*," was passed, we find all recorded opinions of any worth (except Public Moneys Drainage Act, 1846.

those of Elkington, which related to spring drainage), to be in support of, and to merge into, the views advocated by either Smith of Deanston, who was the first acknowledged advocate of systematic draining, or by Josiah Parkes, whose philosophical publications on the same subject gave a scientific bearing to it quite irreconcileable with the more mechanical rules laid down by Mr. Smith.

Views of Smith of Deanston.

The characteristic views of Smith were—

1st. *Frequent* drains at intervals of from 10 to 24 feet.

2nd. *Shallow* depth—not exceeding 30 inches—designed for the single purpose of freeing that depth of soil from stagnant and injurious water.

3rd. "*Parallel drains at regular distances*, carried throughout the whole field, without reference to the wet and dry appearance of portions of the field," in order "to provide frequent opportunities for the water *rising from* below and falling on the surface to pass freely and completely off."

4th. *Direction of the minor drains* "down the steep," and that of the mains along the bottom of the chief hollow; tributary mains being provided for the lesser hollows.

The reason assigned for the minor drains following the line of steepest descent, was that "the stratification generally lies in sheets at an angle to the surface."*

5th. *As to material*—Stones preferred to tiles and pipes.

Views of Parkes.

The characteristic views of Parkes, at that time, were—

1st. *Less frequent drains*, at intervals varying from 21 to 50 feet, *with preference for wide intervals.*

2nd. *Deeper drains at a minimum depth of 4 feet*, designed with the twofold object of not only freeing the active soil from stagnant and injurious water, but of converting the water falling on the surface into an agent for fertilising; no drainage being deemed efficient that did not both remove the water falling on the surface, and "keep down the subterranean water at a depth exceeding the power of capillary attraction to elevate it too near the surface."

3rd. *Parallel arrangement of drains*, as advocated by Smith of Deanston.

4th. *The advantage of increased depth*, as compensating for increased width between the drains.

5th. *Pipes of an inch bore the "best known conduit"* for the parallel drains. (See Evidence before Lords' Committee on Entailed Estates1 1845, Question 67.)

6th. *The cost of draining uniform clays should not exceed 3l. per acre.* (See Evidence before Lords' Committee, 1845, Questions 151 and 252.)

* There is no doubt that all stratification that outcrops at the surface must describe an angle with it; but Mr. Smith was wrong in asserting that the soils operated upon by drainage "generally lie in sheets." Lamination of soil is found to be the exception, not the rule.

Such were the published views of the two most prominent advocates of systematic drainage at that juncture in British agriculture, when the Legislature constituted the Inclosure Commissioners the directors of the drainage of entailed properties and the arbiters of contested opinions.

The practice of the past afforded to the Commissioners no satisfactory and conclusive precedents to guide them, and as it was necessary to lay down some rules to regulate the expenditure of money—the public money chargeable on future generations—they were bound to adopt such as appeared to them best calculated to secure permanent and economical work, although those principles were based on modern views rather than olden usage.

Mr. Smith's, or the "shallow system," aiming only at getting rid of the enemy, was most popular in the country, because the object was simple, and it more nearly approximated to past practice. Mr. Parkes's, or the "deep system," on the contrary, aiming at the conversion of the enemy into a friend, was only acknowledged in the first instance by the few whom his most admirable "Essay on the Philosophy of Draining" had converted to his views. The Commissioners recommended for adoption the main principle of Parkes's system—*increased depth*—and without pledging themselves to the details, left much to the good sense of landowners, the judgment of their inspectors, and the general progress of knowledge on the subject.

Inclosure Commissioners adopt deep drainage as the rule when disposing of the public money.

It was absurd to suppose, although it has frequently been asserted to be the case, that the Inclosure Commissioners, in preferring deep to shallow drainage, necessarily adopted Mr. Parkes's views with respect to 1-inch pipes (pencil-cases, as Smith used to call them), or the fallacious and mischievous assumption, that effective draining of the average of soils may be executed for less than 3*l.* an acre. Yet no manifestation was made by the Commissioners in disapproval of the rule laid down by Parkes, that depth might govern distance between drains in something like mathematical ratio.

It is to be regretted that *extreme cheapness* in the permanent work of drainage ever found so powerful an advocate as Mr. Parkes; whilst it is even more to be regretted that such a seductive claim to the attention of landowners, and the fallacious means by which it was supported, was not disclaimed by the Commissioners, when by stereotyped tabular forms they compelled all applicants for borrowed money to conform to *method.*

Every person who has had any extent of practice in draining will bear witness to the frequency with which a landowner (whose knowledge

of the subject might be limited to the reading of Mr. Parkes's writings) has met an estimate of 5*l.* or 6*l.* an acre with the exclamation, that "Mr. Parkes says he can drain at 3*l.* an acre;" and when a distance of 21 or 24 feet apart between drains 4 feet deep has been recommended, the same landowner has ejaculated, "But observe the instances quoted by Mr. Parkes of 4 feet drainage, in the Weald clay of Kent. Mr. Parkes shows there that the work was done effectively by Mr. Hammond, at 50 feet apart, with inch-pipes, for 1*l.* 11*s.* 9*d.*"

Extreme cheapness false economy.

In the desire for economy, soils that should have been drained from 18 *to* 25 *feet apart, have been drained at from* 30 *to* 45 *feet, and yet the average actual cost of parallel drainage, executed in Great Britain within the last eight years, will be found to be at least three times the cost here instanced by Mr. Parkes, and which he gave, in* 1846, *as a guide to future cost of drainage in this country.*

Real cause of prevailing disappointment, 1854.

I have laid considerable stress upon the fact that under-draining was first introduced, as a general (government) system, under the false pretensions of extraordinary cheapness, because I consider that to that fact, and to the influence of the overdrawn theory, that *depth governs the distances between drains*, is to be attributed the discredit which has fallen upon deep drainage.

(Note, 1883.)

[These are the views I expressed thirty years back, and which I have repeated on numerous occasions since, when called upon to give evidence, or to express any opinion publicly on the subject. Every day's experience has only strengthened them. At the time the paper now reprinted was read (1854) the amount of money expended under the control of the Inclosure Commissioners did not reach two and a half millions sterling. At the present moment (1883), when there has been upwards of eight millions of borrowed capital expended in draining alone, and probably more than one and a half million acres of the land drained with the money, the public mind appears to be as far off as ever from a clear conception of what has prevented deep drainage from being invariably satisfactory, and it is to be feared that this country, and other countries too, may run to reverse extremes to avoid disappointment.]

In the time that has transpired since the passing of the Public Moneys Drainage Act, 1846, up to the year 1854, the average cost of under-drainage has been found to be not "less than 3*l.* per acre," as declared by Mr. Parkes to be the outside cost (see Vol. VI, "Journal of the Royal Agricultural Society of England," p. 126), but more than 5*l.* per acre.

Before we enter upon those details which characterise more or less recognised methods of draining, let us dismiss from our minds the delusion that the drainage executed under the control, or rather the inspection, of the Inclosure Commissioners and their inspectors is any peculiar system. The popular notion of "government drainage," as it is called, no doubt consists of the cutting of under-drains 4 feet deep, 30 feet apart, parallel with a fence, down the steepest fall of the land, and connecting these parallel lines with one main drain, following the lowest ground and discharging at the lowest corner of the field; and there is no doubt that under the influence of probing rods and tabular returns occasional instances do exist in which fields containing a variety of soils, and presenting a diversity of surface, have been drained in uniform parallelism from one side to the other, at an equal distance between the drains. The absurdity, however, of applying any uniform arrangement of drains (as Smith advised) to cases where soil and surface both vary in character is so manifest that it is unnecessary to say that no responsible person could sanction such a "system." And with this remark, therefore, the popular idea in question may, we believe, be dismissed from the minds of all practical men.

Popular idea of "Government Drainage."

But we cannot so readily dismiss the fact that to ignorant and incompetent men is left the execution of drainage under the erroneous impression that any man who offers himself as an expert is competent for the work. It has fallen to my lot to examine many works proclaimed to be failures, and in nearly every case I have been enabled to discover glaring defects in design or workmanship, which would alone explain the cause of failure without any reference to governing principles;—[and I have not unfrequently discovered one of the rejected foremen of the General Land Drainage Company operating as "Engineer," under the supposition that such an arrangement was economical.]

[That much dissatisfaction with clay land drainage does exist no one conversant with the facts can doubt; and that that is due to the placing of the under-drains at intervals too wide to be consistent with the true theory of under-drainage, which insists upon *perfect aëration of the soil from surface to drain, and from one drain to the next, is equally certain.*

(Note, 1883.)

In my lectures given before the Royal Agricultural College at Cirencester in 1865, "*The theory of under-drainage as accepted by a practical man*" was thus explained (see "Practice and Science," by John Constable, M.A., Principal of the college):—

Original paper, 1865.

Theory of under-drainage *practically* explained, 1865. (Reproduced 1883.)

"All wet soils may be divided into four classes:—1st, free soils; 2nd, clay soils; 3rd, peaty and vegetable soils; and 4th, mixed soils consisting of different proportions of these three.

"1. *Free soils* (non-retentive), in their undrained state, gradually get rid of the water as it rises from the subterranean level, by evaporation from the surface, by the demands of vegetation, and by percolation through the soil from a higher to a lower level, from whence it finds discharge at the surface.

"2. *Clay soils* (retentive), in their undrained state, retain nearly all the water they absorb, until it be released by evaporation or appropriated by vegetation. A very small proportion oozes from the clay strata into the rivers, or into the free soils and porous rocks with which they are in contact. The water which they do not absorb finds its way over the surface to the arterial channels.

"3. *Peaty soils*, being greatly capable of suction or capillary action, likewise give off, in evaporation, a large proportion of the water they absorb while in their undrained state; but the effect of draining is much more active in them than in clay soils.

"4. All lands which are not distinctively free soils, clays, or peaty soils, will be found to partake of these characters in varying proportions, and in their undrained state retain water and give off vapour in proportion to the clay they contain, and their capability of natural drainage.

"Each description of soil has its appropriate mode of drainage; but the atmosphere takes such a prominent part in bringing about the desired mechanical changes in retentive clays, that it is positively necessary to regard the mode of draining them as distinctly different from that of draining free soils.*

* Irrespective of cost you cannot put too many drains in clay soils, whereas in free soils it is the *ne plus ultra* of good work to reduce to a minimum the number of under-conduits by which to relieve the land of stagnant water. Test-holes decide the number with accuracy; and, wherever test-holes are the guide of operations, parallelism is the exception, and not the rule. It is found that, practically, the clay lands cannot be drained by the guide of test-holes. The expansive character of the soil, and the action of the atmosphere upon the side of the test-hole, do not admit of the water passing from the test-holes to the drains with that ready response to the rainfall which is to be observed in free and mixed soils. The recognition of this fact will confirm the classification of wet soils, by distinguishing the soils that can be drained by test-holes, and which reject uniformity of design, from those which cannot be drained by test-holes, and which require that complete aëration which is only to be gained by the reciprocal influence of one

"The surcharged free and peaty soils, being naturally "*percolative*," are only wet from position, and they require just sufficient outlet for the water pent up within them to turn stagnation into motion, and to create, in point of fact, a subirrigation for the benefit of the roots of vegetation. You have observed, no doubt, the effects of *moving* water on the surface of our irrigated meadows, and have seen that it is not wetness that is wanted, for these meadows are generally too wet before the water is turned on, but that it is *motion;* and so it is with the under-drainage of our free soils. In them the true art of draining is in doing only as much as will attain this object. When once drained, they possess the same capabilities as those which are naturally dry, and they are equally susceptible of absorption, the only difference being the depth of the subterranean water-level, which, in the case of the high and dry lands, sinks down beyond the reach of evaporation; while, in the case of drained lands, though the water-level is lower than in undrained lands, it still remains within reach of the atmosphere. Theory of under-drainage.

"The clays, on the contrary, though rendered capable of the "*permeation*" of water by under-drainage, still hold their peculiar powers of retention and expansion, which limit their capabilities of absorption, and cause them to resist, when the surface is not properly and deeply cultivated, the admission of falling rain. Clays hold the moisture they seize, and give it out gradually except on occasions of heavy downfalls, when, after their own capacity for retention has been satisfied, they readily discharge the excess. *These soils cannot be aërated too much*, as it is only by complete aëration that their retentive nature can be held in subjection. In clay lands, the more perfectly the drains tell upon the mass of soil between them, the quicker and more uniform will be the passage of surplus water through that mass. The true art of draining is not confined to ejecting surplus water, but extends to the complete aëration of the soil drained. You must bear in mind that all the drainage in the world will not alter the constituents of clays; it merely alters their condition. When fitly treated, clays are as grateful as any; when abused they become the *noli me tangere* of soils. Complete aëration essential.

"In free soils, which are not subject to expansion, and through which water descends by *percolation*, as evenly as through a fine sieve, you will readily understand how simple the effect of drainage is.

"But it is not quite so easy to those who have not minutely watched

drain upon another. (*From a paper by the writer, read before the Royal Agricultural Society of England, March 18th*, 1863.)

Theory of under-drainage.

the effects of drainage on clay soils to understand that water and air will penetrate their bulk. Their retentive powers, and their expanding and contracting qualities, always at work as water is absorbed and withdrawn, are peculiarities which render them altogether dissimilar from free soils. The water that is instantly absorbed and percolates a free soil finds a check in clays which may not be broken up by deep cultivation; and were it not the fact that there are few clays that are not threaded with natural sand and gravel veins, more or less minute, and that there are none which do not crack as they contract, the believers in impermeability would gain ground. No water can be taken out of clay soils by drainage or by evaporation without contraction, and there can be no contraction laterally without cracks. The space the water has occupied in the soil is then claimed by the atmosphere, and the under-drains convert those cracks into constant channels fixed and secured by the minute particles of soil formed by disintegration which descend with the rain, and prevent the re-adhesion of their sides. The greedy capacity which enables clay soils to absorb water weighing from 40 to 70 per cent. of their own weight is thus counterbalanced by a natural law which imperceptibly obliges them to give it up again to drainage and the atmosphere. Each year after drainage the disintegration becomes more perfect, and the ramification of the cracks and fissures more and more minute, and thus the soil becomes more susceptible to the influences of gravitation downwards to the drains, and capillary attraction upwards to the surface. The best evidence of this gradual amelioration of clay subsoils is to be gained by the microscope, by which it will be seen that both their texture and colour undergo decided change in the course of a few years from the effects of air and water penetrating them."]

The heads under which I shall divide the subject will be three in number, and may thus be taken—*Depth of drains—Distance between drains—Arrangement and direction of drains.*

Depth of drains.

I. *Depth of drains.*

The evidence I have collected is so condemnatory of shallow drainage, and with only one exception so much in favour of the deep system, that I consider the superiority of the latter incontestably proved. Of course I am now speaking simply of "depth," irrespective of other considerations.

Cases without number may be quoted in which the results of an indiscreet desire to economise have completely disproved the theory

that increased depth will compensate for increased distance between drains.

Mr. George Beaumont, jun., of Bridgeford Hill, writes—

"I have had painful experience that no extra depth will compensate for too great distance between the parallel drains. I have seen drainage well executed on strong land fail miserably because it was drained 30 and 36 feet, when at 24 feet apart the drainage would be effective."

Mr. Gow, of Morpeth, says—

"I have had one or two failures in deep draining, where, from a desire to economise, I have placed the minor drains at too great a distance apart; and I find too that some of our earlier performances at a depth of 3 feet will require to be re-drained at a greater depth."

Many similar cases could be given, but it is not every one who, like Mr. Beaumont and Mr. Gow, will volunteer the admission of failure for the benefit of others.

But these instances, though they prove that drainage is not so cheap an operation as was supposed, do not affect the abstract question of the superior efficacy of *deep* drains compared with *shallow* ones.

We have numberless instances of deep drains taking the place of shallow ones, and effectively draining land not hitherto drained, although excoriated with shallow drains; while it is difficult, if not impossible, to name a single case where deep drainage, *properly executed* and on a good system of arrangement—*i.e.*, with drains near enough to each other to secure complete aëration of the subsoil between drain and drain—has failed.

So numerous, indeed, are the instances throughout Great Britain of the complete success of deep draining as a principle, that it is difficult to school the mind to the expediency of a compromise of that principle under any circumstances whatever, although it is clear that the cost of thoroughly draining the dense clays of certain geological formations, from the lias upwards, far exceeds the economical anticipations which gave a stimulus to drainage operations under the first Drainage Loan Act.

It will be our duty, nevertheless, before reducing the depth of drains in order to lessen the outlay, to consider well the objects of deep drainage. "Deep drainage" must not be regarded simply as a means of discharging surplus water, but of rendering active and suitable for the roots of plants, when that water is removed, a greater depth and quantity of soil than would otherwise exist. The writer of the article

Dr. Lyon Playfair's description of the "Theory of deep drainage."

on the *Theory of Drainage*, in the "Cyclopædia of Agriculture,"—Dr. Lyon Playfair—says,—

"By adequately deep drainage the temperature, and therefore the climate, of the soils is elevated; their porosity for moisture, though not for *wet*, is increased; their disintegration is effected, and nutritive soluble materials are liberated; the organic gaseous food of plants is furnished by absorptive action in greater quantity than before; and the injurious organic and mineral ingredients of the soil are so far altered as to be positively beneficial to vegetation."

As it is much more easy to deny than to demonstrate a theory relating to the soil on which we tread, and which our eyes do not penetrate, the susceptibility of compact clay soils to maintain a level water-bed at a depth closely approximating the depth of the under-drains must remain a subject of doubt with many; but we are unacquainted with any proof that water will disobey the laws of gravitation, or will fail to descend through any clay soil, to the approximate level of drains of reasonable depth, *if they be placed sufficiently near* each other to counteract by aëration their absorbent and retentive properties.

It is not essential to prove that a precisely straight line from drain to drain marks the line of water-level in a clay subsoil; but it is essential to a right understanding of the question that we should acknowledge that the effect of perfect drainage is so to alter the condition of the soil that a free passage is afforded through its entire mass for water falling on the surface. I do not at this moment know a better means of illustrating the passage of water through clays aërated by perfect drainage than by observing the action of rain falling upon a window-pane. It will be seen that the inclination of each drop of rain is to fall vertically down the pane, but in consequence of prevailing passages or courses (answering to the fissures or sand veins in clays) the drops as they fall are frequently diverted to the right or to the left until they reach the bottom of the frame. This wayward course of the rain down towards the bottom only holds until the pane is completely wetted, when we lose all trace of the passages of rain down it; so in the clay soils, the surface water finds its way to the drains by a general commingling of water through the mass of soil after it has got thoroughly wetted to the level of the stagnant water existing in the subsoil at the level of the under-drains.

No one can deny the superior productive capabilities of a deep bed of active soil compared with a shallow one; no one denies that rain-water in *circulating* through the soil is a benefit and not an evil to vegetation; neither is it doubted that the effect of deep drains in a free and porous

subsoil is to diminish evaporation and raise its temperature; but there does appear to exist a considerable doubt *whether even 4 feet drainage is sufficiently deep to "overcome succulence" and prevent excessive evaporation from the surface of the denser clays*, and this doubt arises from the continuance of those clays to crack widely, after drainage at moderate intervals.

Coldness of soil.

I use these terms, "overcome succulence" and "prevent excessive evaporation," because Mr. Parkes, in defining effective draining, said that it should be sufficiently deep "to keep down the subterranean water at a depth exceeding the power of capillary attraction to elevate it too near the surface," and Mr. Gisborne, the contributor of the article, *Agricultural Drainage*, in the "Quarterly Review," No. 171, thus expressed himself on the same point:—"Moreover, no sooner will the soil hold water of attraction, than evaporation will begin to carry it off, and will produce the cold consequent thereon." "The system of saucer-watering is reprobated by every intelligent gardener; it is found by experience to check vegetation; besides which scarcely any cultivated plant can dip its roots into stagnant water with impunity. Exactly the process which we have described in the flower-pot is constantly in operation on an undrained retentive soil." "At 18 inches, attraction will, on the average of soils, act with considerable power. Here, then, you have two obnoxious principles at work, both producing cold, and the one administering to the other. The obvious remedy is to destroy their *united* action; to break through their line of communication. Remove your water of attraction to such a depth that evaporation cannot act upon it, or but feebly. What is that depth?" That is the most difficult and the most important question connected with drainage.

The effect of evaporation. (Note, 1883.)

[Every one knows that the only way for the rain which has been absorbed by land, and which does not infiltrate to a subterranean level, to escape, is by evaporation; and though perhaps not equally well known, it is equally true, that heat disappears or becomes latent by the conversion of water into vapour. It is this effect on the moistened skin that produces cold in human beings when they expose themselves to the action of the air, and precisely the same evil attends the exposure of the moist soil to the sun and wind. An application of this homely bit of philosophy has led to the manufacture of ice in the hottest climates; and I once convinced a doubting farmer of the chilling effect of evaporation on his land by hanging a bottle of his port wine clothed in wet flannel before a kitchen fire, and proving by comparison that it became cooler.

To reduce the effect of evaporation to tangible figures, I may state that every gallon of water carried off from the soil by evaporation robs the soil of as much heat—heat, remember, which is beneficial to vegetation—as would raise $5\frac{1}{2}$ gallons of water from freezing to boiling point. You cannot be surprised, therefore, that saturated lands within reach of the sun or wind should be called "cold" as well as wet.

Heat conveyed to soils by water and air.

Heat will not pass downwards in water, and, if the soil is saturated, the warmth of the atmosphere cannot penetrate it. Heat is propagated in water by circulation, that is, by the upward movement of the heated particles, and the downward movement of the colder ones to take their place. Heat is conveyed to a soil by the circulation of the air and water through its recesses, and this fact, considered in relation to what I have before said, will help to explain how it is that water occupying the interstices of the subsoil by capillary attraction, is forced downwards by descending rain, and an improved temperature gained to the subsoil.

Dew.

What part dew and atmospheric moisture take in underground circulation we cannot so precisely state, but it may be safely believed, that when air highly charged with moisture passes through the earth, it must, by contact with the subsoil, part with large quantities of moisture for the benefit of vegetation. It is this which gives a freshness in dry weather to the grass above mole-tracks, and makes the courses of drains so distinguishable on the surface.—*From the writer's lecture entitled "The theory of under-drainage as accepted by a practical man,"* 1865.]

As the denser clays are soils of less productive value, and therefore susceptible of less increase in renting return by drainage than clays of a milder description, there are many owners of such clay lands, who, while approving the principle of deep drainage, are disposed to take the view of the late Sir Robert Peel, who, addressing Mr. Gisborne, said:—

The late Sir Robert Peel's compromise.

"I can conceive a case in which, if you had a limited sum to expend (say 4*l.* per acre), the nature or the ground might be such that the increased closeness might compensate for diminished depth; I mean, for instance, that drains 18 feet apart and 3 feet deep might be more effectual than drains 25 feet apart and 4 feet deep. It is utterly untrue that I am dissatisfied with the experiment of deep drainage."*

Now we all know that there are thousands of acres lying on the Lias, Oxford, Kimmeridge and London clays, and I believe I may add the

[* Sir Robert Peel added: "If I had a field in my own occupation of stiff clay I should place close drains 21, or perhaps 18, feet apart; but I should prefer 4 feet, notwithstanding the additional expense, to 3 feet."—April, 1852.

Wealden clay, of which the present rent in an undrained state does not exceed 10*s.* to 16*s.* per acre, and which, to be drained perfectly, with reference to climate as well as soil, will *require the drains to be placed from* 18 *to* 24 *feet apart.* We can well understand the very legitimate doubt which does and will arise to the minds of deep-draining men as to the expediency of going to the full depth in such soils—soils which, in low times, agriculturists are very disinclined to embark capital upon under any circumstances, and without which it is useless to expect a full development of the benefits of drainage. The practical way to decide this question is to compare and be ruled by cost —*irrespective of which there appears to be no hesitation in adopting the greater depth.* [*Observe, this was written in* 1854.] Let us take the case of land on the Oxford clay, which, we will assume, for argument sake, will not support an outlay exceeding 5*l.* per acre, which is equal to 7*s.* per acre rent charge for a twenty-two years' term, and compare the cost of draining it by a parallel system of 27 feet intervals 4 feet deep, with the cost of 21 feet intervals 3 feet deep, assuming the cost of the 4 feet work to be 6½*d.* per rod, the cost of the 3 feet 4*d.* per rod, and the price of pipes for minor drains 18*s.* per thousand.

Comparative cost of 3 feet and 4 feet deep drainage.

	27 × 4			21 × 3		
	£	*s.*	*d.*	£	*s.*	*d.*
Cutting and filling	2	13	0	2	1	10
Pipes	1	10	6	1	19	2
Haulage	0	4	3	0	5	5
Pipe-laying and extra for mains, clearing outfalls, iron outlets, and masonry	0	11	8	0	13	0
Total	£4	19	5	£4	19	5

A gain of two yards in nine is considerably in favour of aëration and a rapid discharge of the water of drainage. But in gaining this advantage we lose the extra foot of active soil, which belongs to the 4 feet work. The cost of draining 4 feet deep at the narrow intervals, taking the same scale of prices, will be 6*l.* 6*s.* 8*d.*, but this proposition, though the right one, would involve an expenditure of 1*l.* 6*s.* 8*d.* more than it was assumed the land would bear, and it is therefore beyond the present question, which is limited to the simple comparison of effects produced by a given outlay.

Of clays lying on chalk sub-soil.

Having stated the fact that there exists a limited, though well-founded belief, that 4 feet drains fail to diminish evaporation from the surface,

or to "overcome the succulency"* of certain clay soils, it is necessary also to affirm that there is a conviction among practical men, who fully appreciate the benefit of deep drains, that they may be too deep as well as too shallow. That there is a depth at which clay subsoils cease to be influenced by under-drainage, is shown by nature. We find the diluvial clays which cap the high chalk hills, although but 10 or 15 feet in thickness, require the aëration of *frequent* drains to render them capable of absorbing and infiltrating surface water; and we find in draining these clays, that as soon as the chalk ridges beneath are touched by the drain pipes away sinks the water of drainage into the basin beneath—a basin which had always existed, without any effect on the water upheld by the clays. And this instance is only a type of many proofs that the well-sinker might adduce of the existence of a porous and dry stratum existing beneath a wet one, or of a deep clay bed being comparatively dry at 20 feet, and wet at 10 feet. In several parts of England advantage is taken of a natural drainage existing beneath wet clay soils, by concentrating the under-drains at sumpts, or holes, called "swallow-holes," penetrating the clay into the porous stratum beneath; but this practice appears to be open to objection, in consequence of the frequency with which the drainage water will rise and cover the surface of the ground when the substratum refuses to absorb the water discharged from the drains with sufficient rapidity.

Swallow-hole drainage.

In our present ignorance of the state of the earth at various depths from the surface, and of the influences at work beneath to produce changes of condition, it appears to be presumption to say, as it is frequently said by enthusiastic deep drainers, that drainage cannot physically be too deep. We may all observe that the force of gravitation fails to saturate clays beyond a certain depth, though we find in the adits of coal mines that the floors rise as well as the roofs sink, showing that there is either immense compression by gravitation of the earth's crust or a pressure from beneath as well as from above, of which we cannot estimate the power.

We have referred to that class of clay lands, the natural poverty of which may render it expedient, under circumstances, to make a compromise with principle; it will be well now to state that there exists a strong feeling with many intelligent men, that low meadow land should be treated differently to upland pasture, and upland pasture differently to arable land.

* See Mr. Blamire's Evidence before Lords' Committee, Question 37, 1849.

Meadow land.

The description of meadow land to which I particularly refer, is that which has a free and porous subsoil. The argument of those who advocate deep drainage in all soils without exception, is that in meadow and pasture land the effect of deep drainage is to displace aquatic, sour and rank herbage by the substitution of sweet, nutritious, and early grasses; while the reply of those who take an adverse view, with respect to meadow land, is that after you have taken a crop of hay, a full aftermath is more likely to be obtained in the months of September and October, when feed is generally scarce, by the retention of the water-level within 3 feet of the surface than at a greater depth. Any advantage, they say, which you may gain by an early bite between Candlemas and May-day, on land drained more deeply, will not compensate for the loss of quantity in the autumnal months of scarcity.

Pasture land.

My own observations bring me to the conclusion that it is not possible to lay pasture (*clay*) land too dry, for I have invariably remarked—during the recent dry summer and autumn particularly—that both in lowland meadows and upland pastures, those lands which have been most thoroughly drained by deep and frequent drains are those that have preserved the most profitable herbage. With free soils it may be otherwise, and I should not have referred so pointedly to the differences of practice prevailing, had I not observed in some of the Fen districts, that water is introduced into the ditches during the later months of the summer, and in autumn, in order to maintain vegetation, which it is believed would otherwise prematurely dry up and decay.

Effect of stagnant water on trees.

This fact would seem to favour the views of those who would except meadow land, with a free subsoil, from the deep drainage system; but in contradiction to this let me refer to a curious circumstance favouring the opposite view. During the wind storms of the summer of 1853 a great many trees were blown down in various parts of the country, and it was observed that the trees in the flat valleys suffered most, and I remarked in the valleys of the Test and Anton, in Hampshire, and in that of the Trent, in Staffordshire, that the numerous trees blown down exposed to view a flat bottom of roots, which had evidently fitted to the surface of the water-level in the land of the valleys, and I found by the aid of a spirit level, that although the depth of soil attached to the roots was different with different trees, the height of the flat base upon which the trees so insecurely stood was identical with the constant water-level of those valleys; and I came to the conclusion that if a stagnant water base was so forbidding to the roots of trees, it could not be very whole-

some for perennial grasses, for it was evident that vitality ceased when the roots reached the standing water-line.

I submit that upon the first point, *depth*, the results of the practice of the last few years have confirmed (apart from other considerations) the soundness of the principle of a minimum depth of 4 feet, where outfalls will admit of it.

(Note, 1883.) Evidence, May 1880.

[The above was spoken in 1854. When under examination before the Royal Commission on Agriculture, on the 4th May, 1880, the writer gave the following answers to the questions put to him:—

"Do you still hold to the opinion that 4 feet draining is desirable under all circumstances?—I certainly am bound to confess that if I had some drainage that I have executed to do again I should drain it differently; but I do not take to myself any blame for that. It was a law; it was a rule of the Inclosure Commissioners to drain 4 feet deep, and nothing under 4 feet deep. That required a certain width, a certain distance between the drains, to bring the cost to a reasonable amount, and land was drained 30, 33, and 36 feet apart, which, if I were to drain again, I should not certainly exceed 27 feet in interval; 21 and 24 and 27 feet would be the width that I should take for the 30, 33, and 36 feet. The Commissioners are now, I believe, acting upon that view, and they no longer require 4 feet, except in cases where their inspector considers that 4 feet is the best depth at which to drain.

"Do you find that the farmers on estates where draining has been carried out with borrowed money have objected to the cost?—Yes.

"And also they have found that the great depth has not been so effective as they desired?—They have attributed to depth that which was rightly attributable to distance. It is a mistake to consider, as farmers generally do, that water will not go down to a drain because it is 4 feet. The real fact is that in order to bring the drainage within a reasonable cost, with a positive rule as to depth of not less than 4 feet, people have drained wide, and wider than they ought, and now we are draining closer."]

Distance between drains.

II. *Distance between drains.*—The indiscriminate adoption of the dictum, that "the *deeper* the drains the *wider* may be the intervals between them," has brought more discredit upon systematic draining than any other rule which has been put in practice for the furtherance of economy;—and the unsatisfactory results that have followed its adoption on the stiffer clays and in humid localities, have caused not only the promulgation of new designs, or "systems," but they have fostered increased earnestness with those who still advocate a shallower depth than 4 feet. Mr. Parkes, I believe, started this theory, and a desire to keep down the cost of drainage works has maintained it in practice up to this time (1854).

Already have Lord Wharncliffe, Lord Fortescue, Mr. Barnett, and, I believe, other landowners, adopted the mixed system of deep and shallow drains as an amendment of the excessively wide system; but this treatment is so clearly one of compromise, that it can never be recognised as a "system" to supersede an adequately and uniformly deep system, however it may be justified as an amendment of an unduly wide one.

Inconsistencies of uniform distance between drains

When we find the same width and depth adopted in the drainage of clays of different properties, such as the London clay of Essex and that of the coal measures of Yorkshire and Lancashire, and when we find the some rule applied to clays of the same geological formation but differing in the depth of rainfall, and in the duration of wet weather, such as the lias clay of the east coast of Yorkshire, and the same clay of the south coast of Dorset, the inconsistency of practice is manifest indeed.

It is true that when we look closely into the several clays which characterise different geological formations, we find that the closer and more difficult clays to deal with are to be found in the south-eastern portion of England, where the rainfall is less, while those that are more easily drained exist in the northern and western portions of the country, where the rainfall is greater and the periods of rain are of longer duration than in the south-eastern districts. If a line be drawn from Whitby in Yorkshire, to Lyme Regis in Dorsetshire, following the course of the lias formation, it will be found that the clays of the upper strata, which outcrop towards the south-east, are more dense in character than those which occur in the lower formations which are found on the west of that line.

Of clays east of the lias outcrop.

To the east of the lias range, we have in ascending order the following clays:—lias of different qualities, the Oxford and Kimmeridge or oolitic clays of different qualities, the Wealden, the gault of the greensand, the plastic and London clays, and the diluvial and alluvial clays of the more recent deposits. Most of these are truly "clays" in an agricultural sense, and the rainfall acting upon them will be found to be much less in quantity, and to vary much less than that to the westward. Thus we have at Oxford 22 inches, and at Bedford 27, at Cambridge 20 inches, and at Thetford 19 inches, at Epping 26 inches.

Of clays west of the lias outcrop.

To the west of the lias outcrop we have, in a descending order, the following clays:—New red sandstone clays; the Magnesian red marl; the Coal measure clay and Milstone grit; the Mountain limestone; the old red sandstone clay; and the Greywacke beds. All these, with the exception of particular and partial beds, are comparatively open clays,

and would hardly be dignified by brickmakers with the name. The rainfall will be found to increase as these strata outcrop westward. Thus, at Derby, immediately west of the lias range, the rainfall is 27 inches; at Manchester 36 inches; and at Tavistock, in the west, 53·6 inches; and at Kendal, in the north, 58 inches.

Rainfall, from east to west.

We find, from sundry published records, that 141 inches may be taken as the average annual rainfall of the wettest place in the north-west of England, while 19½ inches may be taken as the average fall of the south-eastern district. And we find that the average number of days in the year in which rain falls in the wettest place is two 210, while at Chiswick (which we are obliged to take for want of records from more eastward places) the average number of wet days in the year is 124, with an average fall of 24 inches.

These facts go some way to meet the apparent inconsistency of draining the comparatively open soils of the north and west, at the same interval of space as the closer clays of the south-east; but it does not explain why the lias clay in the dryer climate of the north-east of England (Yorkshire) should be treated precisely like the same clay in the humid atmosphere of the south-west (Devonshire).

The opinion that the soils most frequently called clays in the north of England and in Scotland are "loams," compared to the denser clays of the south-east, is generally received by my northern brethren with derision; but examination would prove that so far as any general distinctions will apply, the opinion expressed is well founded. Of course there are exceptions in this instance, as in all other general rules. These exceptions are to be found in some slowly deposited clay beds in the two red sandstones, in the coal measures, and doubtless in other formations; but they are, though consisting of many thousand acres, of comparatively very small extent, and cannot be said to characterise the geological formation in which they occur. The exceptional clays are very difficult to drain, because they not only exist under more humid conditions of atmosphere, but receive the soakage of surrounding strata more porous than themselves.

(Note, 1883. The old distich exemplifies this—

"When the clay feeds the sand,
Then it's good for old England;
But when the sand feeds the clay,
Then she cries, Oh, lack-a-day!"

TABULAR STATEMENT OF ANALYSES OF DIFFERENT CLAY-SOILS.

Geological description of soil.	Locality.	Average annual rainfall.	Average annual number of days on which rain falls.	Weight of sample dried by exposure to air and sun.	Weight after four days' absorption of water placed within reach of suction. Sept. 26, 1854.	Difference in weight between dry and wet.	Weight immediately after pressure of sample by 6 cwt. into rectangular block 3 inches square. Sept. 29, 1854.	Weight after exposure to air and sun. Oct. 7, 1854.	Proportion of weight lost by evaporation.	Measure of breadth and depth of rectangular block immediately after pressure. Sept. 29, 1854.	Measure after exposure to air and sun. Oct. 7, 1854.	Proportion of external measure diminished by contraction.	Proportion of weight absorbed from the atmosphere after being broken small and dried in an oven. Dec. 2, 1854.	ANALYSES BY PROFESSOR WAY. In 100 parts.			
														Organic matter and combined water.	Sand.	Clay.	Lime.
				oz.	oz.dec.	oz.dec.	oz.dec.	oz.dec.		in.dec.	in.dec.						
1. Diluvial warp clay ...	Portbury, Somersetshire ...	...	...	12	16·00	4·00	14·96	11·96	$\frac{1}{3}$	4·283	4·068	$\frac{1}{20}$					
2. London clay	Regent's Park, Middlesex	26	124	12	17·50	5·50	15·20	12·0	$\frac{1}{3}$	4·667	4·133	$\frac{1}{10}$	$\frac{1}{16}$	5·47	12·35	79·39	2·79
3. Wealden clay	Maresfield, Sussex ...	...	...	12	15·57	3·57	14·20	11·95	$\frac{1}{3}$	4·470	4·050	$\frac{1}{10}$					
4. Drift chalk on Kimmeridge clay, called "white clay" ...	near Horncastle, Lincolnshire ..	...	...	12	14·75	2·75	14·00	11·98	$\frac{1}{7}$	4·300	4·066	$\frac{1}{18}$	$\frac{1}{18}$	1·46	10·07	14·57	73·90
5. Boulder clay on Oxford clay	Haddon, Hunts	...	...	12	17·06	5·06	15·85	12·0	$\frac{1}{4}$	4·680	4·080	$\frac{1}{8}$	$\frac{2}{21}$	4·81	6·92	79·41	8·86
6. Oxford clay with covering of warp-drift	Orton, near Peterborough	...	...	12	15·42	3·42	14·17	11·97	$\frac{1}{7}$	4·400	4·060	$\frac{1}{13}$		2·05	36·52	56·74	4·69
7. Lias clay	Vale of Belvoir, Lincolnshire	...	...	12	15·62	3·62	5·35	11·95	$\frac{1}{8}$	4·570	4·180	$\frac{1}{12}$	$\frac{1}{10}$	4·70	6·80	84·34	4·16
8. Red sandstone from very stiff clay bed	near Warwick	...	...	12	7·20	5·20	16·75	12·0	$\frac{3}{7}$	4·650	4·220	$\frac{1}{10}$	...	2·60	11·12	84·03	2·25

Analyses of clay soils.

The satisfaction which has attended systematic drainage, at comparatively wide intervals, in the north and north-east of England and in Scotland, is to be attributed to two causes; firstly, that when compared with the south-east, the clay soils are generally of a more open character; and, secondly, that when compared with the west of England there is a smaller amount of atmospheric humidity.

Now though experience shows that a consideration of the amount of rainfall is a matter of much moment in determining the width between drains, it does not practically govern the size of the pipes to be used, for if the ends of the pipes can be made to join securely, and the fall is good, the smallest sized pipes will be sufficiently large.

The rainfall in a measure governs the distance.

But in reverse proportion to the rainfall, all other considerations being equal, should be the distance of the drains apart, in order that the condition of the soil may be sufficiently free and active at all times to absorb and discharge the maximum amount that can fall on its surface.

But after we have arrived at the amount of rainfall, we have still another inquiry to make; I refer to the number of days in which, on an average of years, rain falls. And it is essential to a right understanding of the matter that we should know the prevalent periods of rainfall, for in accordance with the length of time intervening between rains, will be the opportunity for soils to undergo those changes of condition which are essential to disintegration and an improved "climate of the soil itself."

Mr. Whitley says: "The number of days on which rain falls is greater on the western than the eastern coast, but the difference is not such as the relative quantity of rain would lead us to expect. The fact appears to be, that the rain-clouds brought by the south-west winds, though partially drained by the western hills, yet pervade every part of England, and deposit much of the residue of their moisture on the eastern lands."

It is remarkable how differently the rainfall in certain districts will be dispersed over the 365 days of the year. In the west of England, where the rainfall is considerable, an inch fall is dispersed over about as many days as in the east where the fall is less, *i.e.*, over five days; while in some of the wettest places of England it would appear that an inch is dispersed over only half that number of days. Now, if works of improvement, such as drainage, are to be appropriate, it is the more important that we should deal with such local peculiarities rather than

with generalisms and averages. This will be manifest from the facts which the returns of 1847, the dryest year on record, show:—

		Height.	Rainfall.	Wet days.
Beckington ...	Somersetshire ...	265	28·74	151
Scathwaite ...	Westmoreland ...	368	129·24	202
Langdale Head	Westmoreland ...	250	112·95	209

or if we take the next year (1848), and compare the Beckington return with that from Windermere, of which the rainfall approaches more nearly to that of Beckington, we still find the number of wet days bearing the same proportion to the amount of rainfall.

		Height.	Rainfall.	Wet days.
Windermere...	Cumberland ..	116	72·36	230
Beckington ...	Somersetshire ...	265	43·16	219

I consider that the figures go far to prove the deduction I have drawn, that not only should the character of the soil and the amount of rainfall be considered in determining the distance between drains, but regard must be had to the continuance of humidity of the atmosphere.

I submit upon the second point, *distance between drains*—that the results of the practice of the last few years have confirmed the principle, that depth may govern distance in soils of an uniformly open and porous nature; that in the denser clay soils this compensating principle is inadmissible, much clay land having been drained imperfectly from being drained too widely.

III. *Arrangement and direction of drains.*—In order to ascertain the object of a parallel arrangement of drainage, and the abuse to which it is subject, we must revert to the original views advocated by Mr. Smith, of Deanston, and adopted by Mr. Parkes. Arrangement and direction of drains.

Mr. Smith advocated parallel drains at regular distances, for the following reasons. I take his own words:—

"The drains should be parallel with each other, and at regular distances, and should be carried throughout the whole field without regard to the wet and dry appearance of portions of the field, the principle of this system being the providing of frequent opportunities for the water rising from below or falling on the surface to pass freely and completely off."

Mr. Smith, therefore, called it the "frequent drain system;"—for distinction sake, I have ventured to christen this "ready made" practice the *gridiron* system. [It is universally accepted as the right arrange- The parallel (gridiron) system.

ment in all soils of *uniform* character in relation to both subsoil and configuration of surface.]

Mr. Parkes adopted the parallel system at wider intervals, adding that it is the subterranean water to which excessive and injurious wetness is attributable; and that if such water be not removed and kept down at a depth exceeding the power of capillary attraction to elevate it too near the surface, no drainage can be efficient.

And Mr. Gisborne, in the "Quarterly," advocated the parallel system for the reasons assigned by Mr. Parkes, christening the rain, or surface water, "top," and the subterranean water "bottom" water, and characterising all water existing in the soil which yields to gravity, and is discharged by the drains, "*the water of drainage*," and that which resists gravity, and is held up in the soil by capillary attraction, "*the water of attraction.*" I do not wish to place my single views in opposition to opinions so eminent and deservedly influential as those I have quoted, but as the object we have in view is to deal practically with the subject, and to profit by the past, I do not hesitate to say that experience has, to a certain extent, modified, if not contradicted, the distinctions here quoted, and has shown that there are circumstances and positions under which parallel equidistant drains, however near, will not necessarily drain land suffering from subterranean or spring waters, but that special causes of wetness must be met by special treatment.

It appears in fact that there is another description of water which causes injury to land, and which, borrowing the style of phraseology adopted by Mr. Gisborne, may be called "the water of pressure," that water which having a higher source than the land drained, rises by hydrostatic pressure through porous veins, or by diffused means, to the surface to the utter disregard of any parallel *system* of drains. A consideration, too, of the varying inclinations of surface, of which instances will frequently occur in the same field, necessitates a departure from uniformity, not in direction only, but in intervals between drains. Take, for instance, the ordinary case of a field, in which a comparatively flat space will intervene between quickly rising ground and the outfall ditch. It is clear that the soak of the hill will pervade the soil of the lower ground, let the system of drainage adopted be what it may; and, therefore, supposing the soil of the hill and flat to be precisely alike, the existence of bottom water in a greater quantity in the lower lands than in the higher, will call for a greater number of drains. It is found, too, that an independent discharge or relief of the water coming from the

hill, should always be provided, in order to avoid any impediment by the slower flow of the flatter drains. Still, in spite of experience, we often observe a disregard of these facts, even in works which are otherwise well executed to a depth of 4 feet, but which have been subjected to methodical rules, and I feel compelled to remark that it has often occurred to me, when I have observed with what diligent examination the rules of depth and distance have been tested, that if more attention had been paid to the *source* of injury, and to the mode of securing an effective, and in the case of surcharged free soils, a permanent *discharge* of the injurious water, much greater service would be done. In the desire to get rid of drainage water, it has been discharged into the nearest field-ditches, which have become so many elongated ponds to dissipate their contents by evaporation into the air, or by soakage into lower lying grounds, little care being paid to the ultimate and permanent discharge of the drainage water. If we are in fact to profit by experience, we shall be led to modify the parallel system of arrangement by a closer attention to the variation in the texture of the soil, and in the inclination of the surface; we shall make our test-holes much more numerous; we shall look more to a subdivision of fields, which are now too frequently prejudiced by a love of mathematical uniformity; we shall cease to continue the drains of low flatlands up the face of steep hilly ground for the sake of preserving straight lines; we shall look upon all continuous hollows, and lateral valleys, as nature's drains, which cannot be overridden by even the closest parallelism, but must be retained as the proper course of drainage, though the conduit be in future below as it has hitherto been above the surface; and we shall for the same reason apply distinct relief drains to those slacks or planes of lesser inclination, which constantly interpose in fields apparently of one slope and aspect, and which, when drained on one uniform plan, never fail to exhibit tell-tale spots which are not unlike a black eye on a healthy schoolboy's face: the mark of both being signs of weakness. Speaking of the *direction* in contradistinction to arrangement of drains, it would almost appear that this point was already (1854) decided so far as the minor drains go, if one may judge by the very general adoption of the line of greatest descent, though frequently modified, even in ploughed land, by following the furrows when they are straight, or nearly so, instead of crossing the ridges, in strict conformity with the parallel equidistant arrangement.

More comprehensive views desirable.

The irresistible influence of gravitation on liquids travelling through a

free soil, or along a conduit carried *across the fall*, is so evident to all who have studied the effect of drains so laid, and can be so easily demonstrated, that it seems unnecessary to dwell on the point; but I cannot help giving an instance to show that water escapes in the passage. Having remarked a line of moisture showing itself at the surface, at a regular distance below some drains in Warwickshire, carried across the fall, I had it in my power to ascertain with precision the depth of the drain itself by taking the difference of height between the line of the drain (at the surface) and that of the line of moisture beneath it.

I recently had an opportunity in Scotland, too, of gauging the quantity of water travelling along an important drain carried obliquely across the fall, when I ascertained with certainty that although the land through which it passed was comparatively full of water, the drain actually lost more than it gained in a passage of several chains through it.

The very general concurrence—to which I have referred—in the adoption of the line of greatest descent as the proper course for the minor drains in soils free from rock, would almost lead me to declare that there should be no departure from it; but we cannot so readily accept the *equidistant* straight line of drains in soils where high ridges and deep furrows prevail.

Furrow drainage.

In grass lands in the *midland* districts, the *furrows* are generally preferred by the most successful drainers; while in arable land of like character the practice with many has been to disregard them.

In Northumberland and in Scotland, the more frequent plan is to disregard them, both in pasture and in arable; but then we must remember that, as before stated, the lands of the North are much more porous than the high-backed lands of Northamptonshire, Huntingdonshire, Bedfordshire, and Oxfordshire. It would almost appear, from the remarks of some intelligent men, that in some soils, if the *ridge* were selected for the drain instead of the furrow, even better results would follow than if the drains were laid across the ridge and furrow. I observe, however, that the Rev. Thomas Witham, of Lartington Halt, in Northumberland, whose estate is spoken of as being very well drained, states that he has followed the furrows, and that the practice is found to answer best. Mr. Stephenson, of Throckley, and Major Cadogan, of Brinkburn Priory, have done the like. Mr. Barnett, of Bedfordshire, mentions the very successful drainage of 150 acres at Stratton, which, being high-backed lands, were drained in the furrows 2 feet 6 inches

deep, and afterwards levelled. But the land at Stratton is far from the stiffest.

I have tested the efficacy of furrow draining compared with straight line equidistant draining, in the Oxford clay, and I found that in grass land much less water would stand in the test-holes dug intermediate between the furrows than between the drains crossing the ridges; and during four years observation I have been unable to detect any tangible difference between the two, in respect to either quantity or quality of the herbage.

In grass lands, therefore, if from the position of the lands in relation to the homestead, there is no probability of their being broken up, made flat, and laid down again, experience favours the adoption of drainage *in the furrows.*

Main drains.

One of the most frequent errors made in systematic arrangement, arising more from inadvertency than from reflection, is the setting out of main drains in the courses of the lowest ground, without respect to the rate of inclination at which the ground on either side falls towards that hollow. Thus, it will often be observed that a 3-inch pipe, laid at an inclination of 1 in 400, will constitute the main for six or eight acres of comparatively porous land (capable of rapid percolation), of which the lateral 2-inch pipe-drains may be laid at an inclination of 1 in 100. Now, if we calculate the relative capacity and power of discharge of the pipes under these circumstances, we shall find that the mean velocity of the 3-inch main will be 13·60 inches per second, while that of the 2-inch minor will be 24·06 inches, and that the main will discharge 3·40 cubic feet per minute, if full, while the minor drain will discharge 2·65 cubic feet per minute, if full; so that two minor drains will more than fill the main drain, although the discharge from the main may be accelerated by the pressure of water in the minor drains.

This cannot be right; and the practice is often the cause of those dark lines and patches of moisture which we see at the foot of rising ground. If practice forbids the use of pipes of less size than 2 inches, and economy negatives our enlarging the mains, we have only one course open, which is the right one, of assimilating the fall of the main drain as nearly as possible to the fall of the minor ones. In practice, this object will be gained by laying on each side of the hollow a separate main, and raising the head of each upwards into the rising ground. This interferes with uniformity, but it is nevertheless essential to good work.

Relief pipes.

Long main drains are found objectionable, particularly if the fall is less than it should be, and opposed to a sufficiently rapid action of any drainage system. In many instances they cannot be avoided, and then it has been found serviceable to introduce in the line of their course wells or sumpts, with relief pipes, discharging into some existing ditch near at hand, so that if the mains refuse from unavoidable cause to discharge their contents sufficiently freely at their lowest outlet, the water may rise in the wells and find a ready outflow by the relief drains.

Flushing.

When it is desirable to flush the main drains by letting in water from a stream hard by, a supply pipe is turned into that stream with a water-tight flap and fastening; and when it is better to flush them by holding back water of drainage in their upper portions, a flap connected with the drain and fixed in a well will answer the purpose.

It is found that the use of this contrivance for flushing will get rid of the protoxide of iron, which adheres to pipes, about which so much complaint is made.

Air drains

Although there is no doubt that water could not issue from any drain unless there were a pressure of air upon the surface of that water, and that the same water could not descend through the soil to the drain unless it first displaced and was followed by air, experience supports the opinion that air, admitted directly to a long or comparatively flat main drain, will cause an increased rapidity of discharge. It may be opportune to instance a case mentioned by Mr. George Beaumont, of Bridgeford Hill, Nottinghamshire, in which an intermittent issue of a main was made constant by the admission of air. He says: "The drain delivered its water with a stopping action, similar to a pump spout; after air was admitted it discharged evenly and rapidly. The field was steep and the water plentiful." [I have frequently found advantage from the admission of air.]

Mr. Simon Hutchinson, of Grantham, who a few years back published a pamphlet, bearing the scientific title of "Drainage on Hydraulic and Pneumatic Principles," recommended an air drain running along the top of the minor drains, and connecting the upper ends of them. He writes: "I entertain the same views, only in a stronger degree, that I have held for several years past; I am not so entirely bound to a 3-feet drain as you appear to believe, *only I would have no drain of a less depth.* I never drain land without introducing an air drain."

It will be readily understood that as clay will always contract rapidly

under the influence of a passage of air causing more rapid evaporation of moisture than would otherwise occur, one of the benefits of draining is cheaply acquired by air drains, and for the denser clays it may possibly be a desirable thing to do, but in the porous soils it would appear that no advantage is gained by it. Many persons regard the admission of air to drains as an impediment rather than an aid to drainage, but I have not yet seen that assertion proved.

Collars.

The use of collars is by no means general, although those who have used them speak highly of their advantages. Except in sandy soils, and in soils subject to sudden alteration of character—in some of the deposits of the Red Sandstones and in the clayey subsoils of the Bagshot sand district, for instance—collars are not found to be essential to good drainage. In the north of England they are used but seldom, and in my opinion much less than they ought to be; but this opinion, it is right to state, is opposed in numerous instances of successful drainage by men of extensive practice; and as every cause of increased outlay is to be avoided, the economy of collars is doubtful. In all the more porous subsoils in which collars have not been used, the more successful drainers increase the size of the pipes in the minor drains to a minimum size of 2 inches bore. [At the present moment, 1883, we never use any pipes less than 2 inches in bore.]

Size of pipes for minor drains.

Outlets.

Before dismissing details it will be opportune to remark that the proper selection of outlets, and a care for their preservation, are as pre-eminently essential to good and satisfactory work, as anything belonging to drainage. Too many outlets are objectionable on account of cost of their maintenance; too few are objectionable because they can only exist where there are mains of excessive length. A limit of twenty acres to an outlet, resulting in an average of perhaps fourteen acres, will appear by the practices of the best drainers to be about the proper thing. [The outlets (which should be *iron pipes*, set in masonry) I am putting up for the General Land Drainage Company are made by Messrs. Barford & Perkins, of Peterborough.]

Plans of drains very important.

Each outlet, which should discharge into an outfall watercourse with a drop of some inches, should be numbered by means of an iron plate, with date as well as number, let into masonry, and the numbers should be figured on a plan of the lands, having the site of every outlet and the position of every drain marked upon it.

I submit upon the third and last point, *the arrangement and direction of drains*, that the results of the practice of the last few years have

shown: (1) that the principle of parallel equidistant uniformity is applicable only when there exists uniform texture of soil and uniform inclination of surface, and that it requires modification directly the soil varies and the surface becomes irregular; (2) that the minor drains should follow the fall of the ground and be laid in the furrows in pasture land wherever it would be found objectionable to break it up and lay it flat; and (3) that let the arrangement and direction be what it may, a constant and effective discharge can only be secured by the most careful consideration of the character of existing outfall streams and channels.

DIVISION II.

ON THE PROGRESS AND RESULTS OF UNDER-DRAINAGE.

Reprint of portions of a paper (Prize Essay) read before the Society of Arts, December, 1855.

Original paper, 1855.

IT is hardly twelve months ago since I had an opportunity of introducing this subject to the attention of the London Central Farmers' Club, the members of which are for the most part tenant farmers; and it was then suggested to me, that however convincing the evidence might be in proof of the profitable results from systematic drainage, and however interesting in themselves the details of the necessary operations, it was so manifest that drainage, to be satisfactory, must be done effectually and permanently, and must therefore involve such a much larger outlay than a tenant farmer could be expected to make, that my statements should be rather addressed to Owners than to occupiers of land.

Drainage a landlord's work.

The whole tenor of the discussion on that occasion went to show, that considerations of *expediency* were paramount with those whose interest in the soil was limited by the nature of their tenancy, while it was contended that *principle* should rule with those whose interest in the soil was permanent and secure.

This practical view and treatment of the subject could hardly be reprehended, when it is remembered that whereas the average amount of capital employed by occupiers in the cultivation of the inferior wet lands of Great Britain may be taken at less than 6*l.* per acre, the cost of permanently draining these lands would amount to about 5*l.* per acre, so that if the tenants who farm them were to apply their capital at once to this fundamental work, they would be left with only 1*l.* per acre to provide for all the other expenditure on their farms.

Tenants' capital insufficient.

If this is so, the proposition becomes reduced to a practical absurdity, for the average amount of capital actually employed in the cultivation of the inferior heavy lands is known to be insufficient to secure even creditable or profitable treatment, irrespective of draining; and to require a tenant to bury a portion of his already insufficient capital beneath the soil in drainage, under such circumstances, can only lead to the injury of both his landlord and himself.

Bush draining an act of husbandry.

Up to the passing of the first Act for the advance of public money for the purpose of draining, in 1846, the operation of draining, or bush-gripping, as it was more appropriately called, was looked upon as an act of husbandry to be performed by those tenants who had sufficient capital to undertake it at a cost of from 30*s.* to 40*s.* per acre.

Twelve to fourteen years the life of bush drains.

Though the drainage lasted but twelve or fourteen years, the outlay was proved to be remunerative, and such draining was recognised by custom in several counties as an improvement entitled to compensation between outgoing and incoming tenants. Now, so long as the intelligence of the country remained insensible of the manifold advantages of deeper draining, and so long as the operation was covered by an outlay of 30*s.* or 40*s.* per acre, we can readily understand that little necessity existed for any participation of the landowner, but as soon as it was established that the best effects of draining depended upon permanency of execution, and could only be gained by an outlay approximating 5*l.* an acre, the matter assumed much more serious proportions. It was no longer a simple process of husbandry. The act of the tenant, dictated by self-interest, rightfully became the act of the landlord, ruled by principle. The only thing wanted was the means of borrowing money, and of adjusting the outlay between present and future owners in cases where the existing owner had but a limited interest in the land.

Borrowed money wanted.

Pusey's Act, 1840.

Mr. Pusey's Act, of 1840, was the first public effort made to meet this want, and although the Act itself, from its complications, remained inoperative, it effectually established the principle of enabling landowners with limited interests to borrow money for draining, and to charge it upon the lands improved. Mr. Pusey's Act, however, was followed in 1846 by the first Public Money Drainage Act, and, subsequently, by other Acts, including the Private Money Drainage Act, and the three several Acts for incorporating the existing private companies.

Several subsequent Acts, 1846, *et seq.*

The desideratum of money was thus fully supplied, and it is much to be regretted that greater use has not been made of the facilities so afforded, particularly during years like the present (1855), when high

prices are making tenants more than ever solicitous to increase their profits by having draining done, and when they will gladly pay the interest by which the cost will be liquidated, as well as a proportion of the extra expense of doing it at a period of scarcity. I am led to make these remarks because I am made daily cognizant of the fact that there are many landowners who, being deterred by the present high prices of labour and materials, are contented to receive their rents without default, and leave the work of drainage to be done inefficiently by the tenant, *or defer it to a time when they may possibly be obliged to do it without receiving interest, for it is manifest that the time is not very distant when clay lands will be deemed untenantable so long as they remain undrained.*

High price of labour and materials delays drainage.

The several Acts referred to gave different powers, but all confirmed the rule that under-drainage was the legitimate work of the owner, and that the only contribution to be made by a tenant should be the payment of the annual instalment by which the cost may be repaid in a given number of years.

The object to be arrived at by both is to secure the best effect with durability. Already it has been made apparent that the short term of twenty-two years, with all the advantage of the low rate of interest of the Government loan, has necessitated a charge upon the tenants which many, even of the most enlightened, are indisposed to bear as a standing increase of rent,—or it has caused dissatisfaction on another and worse ground, viz., that the works themselves have been inefficiently done, from a predetermination to limit their cost to such an amount as will be repaid by a given charge.

Estates charged for twenty-two years.

I refer to the experience of this fact, because it is manifest that the extension of the art of draining will very materially depend upon the rate of instalment charged upon the tenants, and however profitable individual cases of drainage may be shown to be, the benefit to the nation will be unappreciable, unless we satisfy the tenants generally that during all the vicissitudes of times they can afford to pay the increased rent they are to be charged. The advantage of a lengthened period will be shown by comparing the increased rent a tenant would have to pay to liquidate the expenditure of 5*l.* per acre in fifty years and twenty-five years. In the former case the increased rent would be from 4*s.* 6*d.* to 5*s.* 3*d.* per acre, and in the latter from 6*s.* 6*d.* to 7*s.* 2*d.* The difference is nearly 50 per cent. Now if drainage is substantially done, there is no reason whatever to doubt that the pipe conduits will last at least fifty years,

Terms of fifty years and of twenty-five years compared.

Fifty years and more the life of pipe drains.

and it follows, therefore, that the time for repayment may extend, if need be, to that period. I have examined a great number of pipe drains that have been laid from twenty to thirty years, and have found them as good as the day they were laid.

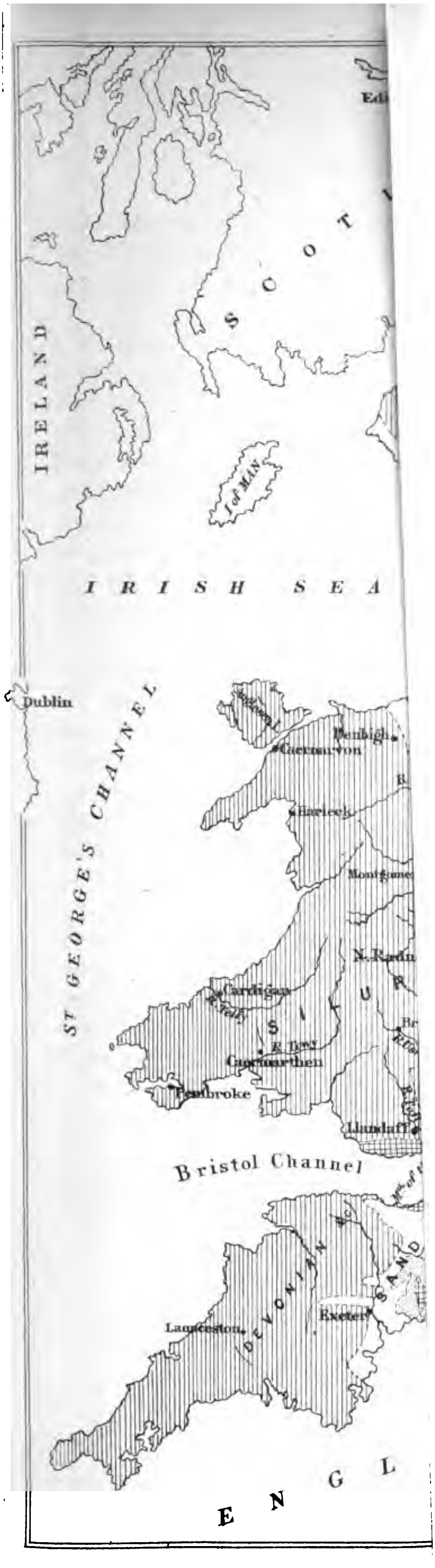
England divided geologically.

To understand clearly the advance made in under-draining, and the extent of work yet to be done, the whole country should be divided geologically into three great characteristic areas, viz., the western and north-western or Alpine district of primary and transition rocks; the middle district of secondary strata, exclusive of, and up to the lower margin of the chalk; and the eastern and south-eastern district, comprising the chalk of the upper secondary strata, the Wealden and the tertiary and post-tertiary deposits overlying the chalk. There are several outlying portions of the formations thus classified which will be found beyond the line of division, but they are so small as not to interfere with the general arrangement.

A curved line drawn from Exeter to Berwick will make a very close give-and-take division between the western and middle districts; and the lower margin of the chalk, commencing at Weymouth in Dorset, and ending at Flamborough Head in Yorkshire, will form a boundary between the middle and eastern districts.

The map of England and Wales, which is here inserted, will enable the reader to trace the course of the divisional outcrops above referred to, and the better to understand the geological districts into which the country has been divided for classification.

It may assist the reader also, when judging of the general accuracy of the following tables, if it be pointed out that the total contents of the *cultivated land* and *land capable of cultivation* in the whole of England and Wales (32,596,600 acres) very nearly amounts to as much as the total area of England alone, and that of the 32,596,600 acres about 14,000,000 consist of arable land, 14,000,000 of permanent pasture, whilst the remainder, 6,596,600, consist of woodlands (1,630,000 acres), sites of dwellings and building land, orchards, gardens, hop yards, public grounds, commons, &c., and waste land capable of improvement. These figures are obtained from the more recent returns of Agricultural Statistics.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ST GEORGE'S CHANNEL
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Cardigan
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[The following tabular statements, first prepared for the Society of Arts in 1855, have been corrected up to the present time, 1883.]

	Acres.	
Total content of England	32,597,398	Total of England and Wales.
„ „ Wales	4,721,823	
Gross total	37,319,221	

I.—Western Division.

Western Division.

The Western and North-Western, geologically termed the Alpine, district, including the Devonian, the Cambrian, and the Cumbrian ranges, embraces the mountainous granite and slate rocks, with the trap rocks, clays, and *débris* associated with them, and the conglomerate clay and loam of the old red sandstone, which cover a wide breadth of the lower lying portions of the district.

The district is made up as follows:—

Name of County, &c.	Extent of Area included in District.	Extent of Land cultivated, and Land not cultivated but capable of improvement, including woodland.	Quantity representing the proportion of Land included in the last column, which, being wet, has been drained, or remains to be drained with more or less advantage.
	Acres.	Acres.	Acres.
Cornwall	870,000	680,000	255,000
Devonshire, Somersetshire, Wales, with Monmouth — parts of	5,672,700	4,215,000	2,250,000
Worcester, Hereford, Salop — part of ...	1,303,700	1,000,000	650,000
Lancashire, Yorkshire, Northumberland, Westmoreland, Cumberland — parts of	1,300,000	600,000	360,000
Outlying portions of these geological formations in the Midland district.	40,000	25,000	10,000
Total acres	9,186,400	6,520,000	3,525,000

II.—Middle Division.

Middle Division.

This portion of the country, including all the outcrops of the secondary formations from the basis of the Devonian, Cambrian, and Cumbrian ranges, up to, but exclusive of, the chalk formation, comprises the mountain limestone, the coal measures, the new red sandstone, and magnesian limestone, the lias, the oolitic strata, and the portion of the green sand with the gault lying to the west of the main ridge of chalk. In these several formations clay abounds, sometimes of very considerable width and thickness, and sometimes only thick enough to act as a parting between beds of porous rock, sand, and gravel. Boulder or transported clays frequently cover the foundation rock and outcropping clays *in situ*. The cultivated lands partake, to a considerable extent, of the ridge and furrow form of surface. The following counties and parts of counties, with a part of Wales, make up the middle division :—

Name of County.	Extent of Counties included in District.	Extent of Land cultivated, and Land not cultivated but capable of improvement, including woodland.	Quantity representing the proportion of Land included in the last column, which, being wet, has been drained, or remains to be drained with advantage.
	Acres.	Acres.	Acres.
Devon, Somerset, Dorset — parts of ...	1,250,000	1,150,000	650,000
Gloucester, Worcester, Salop, Wales, with Monmouth — parts of	2,202,500	1,960,000	1,250,000
Cheshire	700,000	630,000	490,000
Lancashire, Cumberland, Westmoreland, Northumberland, Yorkshire — parts of	6,024,000	5,591,000	3,500,000
Durham	650,000	600,600	500,000
Nottingham	530,000	500,000	350,000
Derby	661,700	540,000	300,000
Leicester	514,000	480,000	280,000
Warwick	570,000	525,000	360,000
Rutland	100,000	90,000	50,000
Northampton	632,000	600,000	375,000
Stafford	750,000	720,000	550,000
Lincolnshire, Norfolk, Cambridge, Huntingdon — parts of ...	1,425,000	1,286,000	950,000
Bedford, Buckingham — " ...	480,000	450,000	250,000
Oxford, Berks, Wilts — " ...	1,050,000	965,000	610,000
Total acres	17,539,200	16,087,600	10,465,000

III.—Eastern Division.

Eastern Division.

This district includes the chalk (the uppermost formation of the secondary strata), the Wealden clay and Hastings sands, the London and Plastic clays, the Bagshot sand and associated clay, the crag of Norfolk and Suffolk, the rich deposits of Holderness, in Yorkshire, and the more recently recovered fens of Norfolk, Cambridgeshire, Huntingdonshire, and Lincolnshire. Boulder and transported clays are also very frequently found in this division covering the outcropping strata.

The following counties or parts of counties make up the division :—

Name of County.	Extent of Counties included in District.	Extent of Land cultivated, including Fen Land, and Land not cultivated but capable of improvement, including woodland.	Quantity representing the proportion of Land included in the last column, which, being wet, has been drained, or remains to be drained with advantage.
	Acres.	Acres.	Acres.
Dorset, Wilts, Berks, Hants, Oxford, parts of	2,203,800	1,130,000	600,000
Bucks and Beds, parts of ...	280,000	265,000	250,000
Cambridge and Hunts, parts of.	546,560	519,000	
Hertford	400,000	375,000	300,000
Middlesex	180,000	160,000	
Surrey	475,000	440,000	1,300,000
Sussex	936,350	900,000	
Kent	996,450	940,000	
Essex	1,015,000	930,000	650,000
Suffolk	950,000	920,000	700,000
Norfolk, part of	1,285,360	1,200,000	
Lincoln, part of	620,000	550,000	600,000
Yorkshire, part of	450,000	425,000	
Outlying portions of these formations within the preceding district.	254,480	235,000	65,000
Total acres	10,593,000	9,989,000	4,465,000

A very wide portion of this division is chalk, and requires no draining. A considerable portion, too, consists of the fens, of which probably half would be benefited by under-drainage. The deep peat or "black fens" may be considered sufficiently well drained by open dykes, and they have not been included in the last column, although the prejudice against under-draining these lands is giving way. Where under-drainage has been tried it has been found to consolidate the soil, and improve the quality and weight of the corn grown. The whole breadth of the fens in the several counties is about 700,000.

SUMMARY.

	Total in each Division.	Extent of Land cultivated, and Land not cultivated but capable of improvement.	Quantity representing the proportion of Land included in the last column, which, being wet, has been drained, or remains to be drained with advantage.	
	Acres.	Acres.		Acres.
I.—Western Division	9,186,400	6,520,000		3,525,000
II.—Middle Division	17,539,200	16,087,600		10,455,000
III.—Eastern Division	10,593,000	9,989,000		4,465,000
	37,318,600	32,596,600		18,455,000
			Dry land and Fen land ...	14,141,600
			Irreclaimable	4,722,000
			Total ...	37,318,600

To form any judgment upon the figures given in the foregoing tables, the reader should carefully compare the last column, containing the estimated extent of *wet land* in each county or collected parts of counties, with the first column giving the total area of each geological division in the same counties or parts of counties.

[To apply these tables to the purpose for which they were prepared —*i.e.*, to exhibit approximately the extent of wet land existing in England and Wales, already drained or requiring drainage in a greater or less degree—the following evidence, given before the Royal Commission on Agriculture in 1880, is reproduced :—

Evidence on the foregoing tables, 1880.

"4705. And I think you said there that 3,000,000 acres only had been drained in England and Wales; that was on page 6 of your evidence?—I did.

"4706. What would you think would be left undrained?—According to the view I expressed (when the foregoing tables were first prepared), it would leave 17,000,000; but on closer examination I have found, exclusive of Scotland, the quantity should be 15,455,000 instead of 17,000,000 acres.

"4707. How do you get it to 17,000,000?—That question will require a lengthy answer, but I will try and summarise what I have to say upon that, and will ask permission to put this paper in, if I may be allowed to do so (*the preceding tabular statements handed in*). In 1855 I was invited by the Society of Arts to read a paper on the progress of drainage, and I went very carefully into the question of what parts of England would be benefited by drainage, and I found, by dividing the country geologically into three parts, and taking the western division to consist of the Devonian, the Cambrian, and the Cumbrian ranges, and embracing the mountainous granite and slate rocks, with the trap rocks, clays, &c., associated with them, and the conglomerate clay and loam of the old red sandstone, which cover a wide breadth of the lower lying portions of the district, that the total acreage of that division was 9,186,400 acres; the extent of cultivated land, and land not cultivated but capable of improvement, I found to be 6,520,000 acres, whilst the quantity representing the proportion of the land which, being wet, had been drained or remains to be drained, I found was 3,525,000. I went through the whole country in the same way, and for the details must refer you to the paper I have put in. The middle division I found to amount in total to 17,539,200 acres, of which the extent of cultivated land was 16,087,600 acres, and the quantity of wet land drained and to be drained, if it ever is drained, was 10,465,000. The eastern division I found to be in total 10,593,000 acres, of which the extent of cultivated land and land capable of cultivation was 9,989,000 acres, and the quantity of wet land, drained and to be drained, 4,465,000 acres. The total of the wet land, drained and undrained, I find, corrected up to the present time, to be 18,455,000 acres, less 3,000,000 drained, viz., 15,455,000.

Total remaining to be drained 15,455,000 acres.

"4710. Did you go over individual farms?—No, I judged of them from information obtained locally, by geological information, and my own experience. I would lay but little stress on the last source, but still I have had pass through my hands 1,000,000*l.* of money, spent in drainage alone, while operating in nearly every county, if not in every county, in England and Wales.

"4711. Do you think that by looking at a geological map of the country you would be able to come to a conclusion as to the amount

of drainage required in any particular given county?—I have no doubt of it.

"4716. Where do you get the information which enables you to say whether that portion of a district has been drained or not, because it depends upon the amount of draining in the district?—If you will allow me to give my data for having said that there was no more than 3,000,000 of acres drained, I will do so.

"4717. (*Mr. Rodwell.*) In England?—In England and Wales there are not more than 3,000,000 of acres drained.

Only 3,000,000 acres drained permanently.

"4718. (*The President.*) You mean properly drained?—Drained in such a way as to pass the Inclosure Commissioners. I am the more anxious to give this answer because the details that I gave before the inquiry in which your Grace took a part have been questioned. They have been questioned in the House of Commons by Mr. Clare Sewell Read, and they have been questioned in an article in the 'Edinburgh Review,' a very able article indeed, and I am very desirous of being able to put before this Commission a statement that will be open to the scrutiny of any one.

"Up to the end of 1872 there had been expended and charged on estates in England, Wales, and Scotland, according to the return of the Inclosure Commissioners, dated March 4th, 1873, the sum of 7,381,049*l.* 19*s.* 1*d.* in drainage alone. From that time to the end of 1879 the expenditure has been increased up to 8,014,312*l.* 8*s.* 6*d.*, by an outlay of 633,262*l.* 9*s.* 5*d.*, which is equal to 90,466*l.* a year on an average for the seven years which have since transpired. I am enabled to give these figures by returns very kindly given me by the Inclosure Commissioners, which I beg to hand in (*handed in.*) If the average cost of drainage per acre be taken at 6*l.* up to 1872, and 6*l.* 10*s.* from 1872 to 1879, the number of acres drained with borrowed money chargeable on the improved estates may be taken to have been 1,230,175 up to the end of 1872, and barely 99,000 acres since, making together say 1,330,000 acres. Of these quantities, certainly the first one-third may be taken to belong to Scotland, the greater share of the public money having gone there, and this would reduce the acreage drained in England and Wales up to the end of 1879 to less than 900,000 acres. That is, that not a million, not one-third of that which I said was the total amount, has been drained with borrowed money, charged on the inheritance. I do not think, your Grace. that any one sitting at this table had realised that fact.

Two-thirds of the country under disability.

"4720. (*The President.*) But that leaves out of view the land that is drained without money borrowed?—Yes; allow me to go on. Now, considering that according to the evidence given before Mr. P. Pusey's Committee in 1839 or 1840, two-thirds of the United Kingdom are under the disability of settlements, and that there is an indisposition on the part of life-owners to spend their own money on land in which they possess but a limited interest, and knowing further that no small quantity of the properties charged under the sanction of the Inclosure Commissioners are properties held in fee simple, it must be evident that the statement that 3,000,000 of acres, which is more than three times the area drained with borrowed capital alone, is really in excess of the total extent of land drained in England and Wales in a manner which

the Inclosure Commissioners would consider fit to be charged on the inheritance.

"4721. I do not quite understand why that is so; I have done some draining on my own estate, and I flatter myself it is remarkably well done?—Of course, I am assuming that twice as much as that which has been drained under the supervision or in connection with the companies has been drained by private owners; and I do not think that there have been 2,000,000 acres drained.

Extent of land drained by owners with their own money.

"4722. But I see you say that you do not believe that 2,000,000 of acres in England and Wales have been drained by private individuals without borrowing money. Why do you come to that conclusion; what are the data upon which you have gone?—Your Grace must not understand that I ventured upon the opinion which I have just expressed, without having well considered the matter, and without having taken pains to satisfy myself in order that I might satisfy others that my opinion is well based. When I read that Prize Essay before the Society of Arts, I corresponded with land agents, and with pipe-makers, who are the best authorities I could go to, as to the quantity of acres drained and the number of pipes sold in their neighbourhood; and I found that two-thirds of the pipes sold were consumed on land charged with borrowed money; and upon that data I reiterate that I do not believe that 2,000,000 of acres in England and Wales have been drained with private capital." [*Extract from the evidence given by the writer before the Royal Commission on Agriculture*, 1880.]

Original paper, 1863.

Exaggerated view prevailing as to the extent drained.

["There is a very general belief that much more under-draining has been done than a careful consideration of facts corroborates. There has been so much said and written on drainage of late years, and the red colour of the pipes as they appear in the fields, like the scarlet petticoat and scarlet cloak that have become so fashionable, make such a display as we travel along, that we can readily understand how the erroneous impression has become general. Very few words will satisfy all doubt upon the point. The utmost extent of land drained under the Public and Private Moneys Acts, and under the several drainage companies' Acts, cannot exceed 1,100,000 acres, as the total outlay up to the present time (1863) does not reach 6,000,000*l.* The drainage of a permanent character executed by landowners with private funds, though very largely increasing, is still much less than the extent done with borrowed capital, and at the present rate of progress it may fairly be assumed that it will take at least a century to complete the under-drainage of the country. To illustrate our present capability to proceed with under-drainage, it may be mentioned that the number of pipe-yards, or brick-yards making pipes, in Great Britain, is estimated at 2,800; and if we assume the number of pipes made at each yard to be on the average 150,000 a year, the total number made in the year may be taken at 420,000,000. The number of pipes now used in under-draining may be taken at an average of 1,250 pipes per acre, and dividing the quantity made by this average we see that 336,000 acres might be drained per annum; but as a large portion of the pipes made are applied to temporary, shallow, and unconnected works, it is not possible to ascertain from such data the extent of *permanent* drainage executed. Assuming, however, that a quarter of a million of acres will, in future, be permanently

Number of pipe-yards in Great Britain.

drained per annum, we may see that a century will pass ere the work is completed. If such is our statistical position with respect to execution, what has been the progress and what our present state of knowledge in the science of under-drainage itself?"—*Extract from a paper read before the Royal Agricultural Society of England—see Journal, vol. xxiv.*]

DIVISION III.

THE EFFECT OF UNDER-DRAINAGE ON ARTERIAL CHANNELS AND OUTFALLS.

Reprint of portions of a paper read before the London Central Farmers' Club, on "The Effect of Under-drainage on Rivers and Outfalls," March, 1862.

Original paper, 1862.

WE must not forget that fifteen years ago we knew little or nothing of under-draining as a system. As I have stated, it was in 1846 that the Legislature, having enabled tenants for life to borrow money and charge their estates independently of reversionary interests, required the Government to protect their interests by supervision and rules. These rules were essential in the first instance, and were imposed on all applicants, so that whatever works were executed, under either of the public or private Acts, obtained the title of "Government Drainage," though the operations themselves were conducted by all sorts of persons. Under the influence of these rules, and as a *a natural consequence of adopting tabular accounts for operations which should necessarily be irregular, when applied to varying soils and surfaces*, a similarity of treatment of all soils became gradually established. The clays and gravels were drained upon the same arrangement, except that the distance between the drains was increased, and frequently the depth also. But little regard was paid in many cases to the minor undulations and irregularities of the surface, and to the influence of higher and adjacent lands, so long as the parallelism adopted would enable the operator to state that the drains were a certain distance apart, and the depth was uniformly 4 feet. Experience has since shown, and is continuing to show, with increasing

Where uniform parallel system applies.

certainty, that uniformity of design can only be properly applied where the surface as well as the subsoil is even and uniform; that, in fact, irregularity of surface in all cases, whether the soil be "free" or "tenacious," must be considered equally with the variation of the soil itself; that whereas you can hardly put too many drains in the stiffest clays, which resist the theory of depth governing distance, a very few comparatively will suffice in a wet free soil, if these irregularities of surface and conditions of subsoil are specially dealt with, and the source and action of the underground water ascertained and properly provided for. The question of depth is no longer open for discussion, though it is not now supported by the false promise of *cheapness*. The only point in the drainage of clay lands in reserve is the number of drains to be applied with a due regard to true economy. A minimum depth of 4 feet is justified on the simple ground of security, and the requirement of the Government (as guardians of reversionary interests), that all drainage, the cost of which is charged on the inheritance, shall be permanent, and, as far as practicable, out of reach of harm. We all know in practice that if a regular inclination is preserved, there must be places in the course of 4 feet drains which approach the surface as near as 3 feet and less, and for the same reason *a 3 feet drain will be only 2 feet in places*. Now as we judge of the strength of any structure by the weakest part, so we must regard the security of under-drainage by its shallowest places; for the steam-engine is no respecter of particular spots, and we are not looking very far forward in anticipating the time when the clay lands of this country will be penetrated by the steam subsoiler; and it is by no means chimerical to state that then we should find 3 feet under-drains, *in their shallowest places*, as far from permanent as the abrogated bush drains have been found to be in their shallowest places by ordinary deep ploughing. Upon this ground alone, if there were no sufficient reason in the fact that every additional inch of vertical depth places from 120 to 140 tons per acre of active soil at the disposal of vegetation, we may congratulate ourselves that the principle of depth has been maintained by the Government in spite of opposition, though it has brought about an inconsistency in our laws affecting waterways, which amounts almost to an absurdity; for while by official rule no under-drains can be executed under a prevailing depth of 4 feet, the common watercourses receiving the under-drainage water are, for the most part, less than that depth; and the Act of last session, with its many valuable powers, for district drainage, affords little

An objection to 3 feet drainage.

additional facilities to private owners for the deepening of party ditches and common watercourses. Where good materials and good workmanship have been adopted, and efforts have been made by the cultivators of ploughed land to facilitate, by deep stirring, the passage of the rain through the first foot of surface soil; by graziers by abstaining from treading with stock the surface of clay land pastures in wet seasons; and by the owners of land by preventing the stoppage of the drains by the growth of tree roots in the pipes, and the silting up of the outfall ditches, there need be no dissatisfaction whatever. The admission of these causes of dissatisfaction, however, does not get rid of them. The number of drains cannot be increased in the stiffer clays without an increase of outlay by the landlord, and the landlord cannot spend more money without expecting a higher interest from the tenant. No money is to be saved by reducing the depth, for the Government positively require that the depth shall not be less than 4 feet, and thus the conflict ensues. With this rule prevailing the only remedy that can be suggested is to save as much money as is possible in the drainage of the free soils, and *with the saving to increase the number of drains in the clays*. It is natural, perhaps, with us all to magnify deficiencies, and pass over the benefits; but I think if we were to compare the insufficiently drained land with the same description of land not drained at all, we should often find less reason for complaint. A tenant of a noble earl in Kent recently consulted me as to a claim of compensation upon his landlord, for the loss he experienced by a small portion of land not being drained as satisfactorily as the rest, and stated that the difference between the land sufficiently drained, and that imperfectly drained, was 8*l.* an acre in the wheat crop he was then about to cut. It was only on my pointing out to him the injury he might do himself by drawing his landlord's attention to the fact that he got an advantage of 8*l.* an acre without any extra effort on his part from the whole extent of the land he admitted to be sufficiently drained, that induced him to withhold his claim. In another case where the owner was occupying his own land, a complaint was made that the water was standing on the surface of his drained land. On going to the spot in the month of February, this year, cattle and sheep were seen in the fields, arable as well as pasture. The severe frost of the previous month had left the land in a state most susceptible of poaching, and the surface was therefore stamped with little basins holding water—frequently directly over the drains. This was in a county where the

Causes of dissatisfaction with drainage

Complaints not always well founded.

proverb rules that it "rains every day in the week, and twice on Sunday." Could the effect be otherwise than it was?

It should be stated, as the result of observations reaching over many years, that the length of the discharging period of under-drains has been found to depend, not so much on the time and quantity of rain falling during the immediate period of discharge, as on the wetness of the preceding seasons. If the preceding winter has been subject to an ordinary rainfall, and the summer has been dry with evaporation active, the discharge of the under-drains will commence late in the autumn; whereas, if a wet winter is succeeded by a wet summer, it is possible that the under-drains may not cease running during the whole year.

Periods of discharge from free soils and clays.

Under ordinary meteorological and physical conditions the under-drains of the "free" soils will begin to discharge in the month of October or beginning of November, and those of the "clays," in the end of November or beginning of December. This difference of time is due, doubtless, to the absorptive qualities of "clays" which seize, and to their retentive powers which hold, the first water which reaches them, as will be presently seen when treating of "clay soils." "Free soils," not possessing the retentive qualities in anything like the same degree, allow any excess to pass away gradually, after the subterranean level has been regained. In a majority of instances, in which "free" soils require under-draining, it is found that surrounding or adjoining lands of a higher level have a great influence upon the extent and continuance of wetness, and this fact interferes, more or less, with the period of discharge. The under-water percolating the soil from a higher to a lower level (designated in my former paper "*the water of pressure*") has much more effect on the under-drainage of land than is generally admitted, and it is the omission to deal with and provide for it properly that is one great cause of defective work, and of the dissatisfaction which is occasionally felt. In fact, in much of the work executed, it has been considered a matter of supererogation to look beyond the four corners of the field to be drained, and to inquire into the real cause of wetness and the source of the evil.

Discharge from free soils.

Before drainage.

Before draining the surcharged free soils, the subterranean water-level, following an universal law of nature, gradually rises higher and higher as it is replenished by autumnal and winter rains. As soon as summer has passed, and evaporation and vegetation slacken their demand and allow any portion of the rainfall to descend to the subsoil, the water-bed begins to rise, and continues rising until the soil becomes

saturated to the surface, when the surface soil—the seed-bed of the farmer—instead of being warm and genial for the first movement of vegetable life, is chilled by evaporation, which by that time has again resumed its power. Early in "February fill dyke" the soil becomes fully saturated, and from that time until the middle of March the ground remains saturated. From this time evaporation gains great power, and the twofold action of slow percolation towards the lowest outcrop and rapid evaporation upwards out-balances the rainfall and gradually lowers the water-bed, and allows vegetation to advance in growth. It is when the "free" soils are filling to the surface that the higher intermittent springs break from the slopes, rising higher and higher as replenishment takes place; and it need hardly be said that it is at such time, too, that heavy and successive rains flow over the surface to the outfalls, and add to the "freshets" which at times crowd the valleys.

After drainage.

The effect of under-draining on this description of soil (and in truth on most of the mixed soils) will be readily understood when it is observed that no water can run from the under-drains until the water-bed has been raised by descending rains to the level of the drains, and that as the surface springs rose higher and higher before draining, so the lowest drains will begin to run first, and as soon as the water-bed of the whole area drained, forming an inclined plane, has risen by degrees to the height of every drain, the whole system will be at work, and not till then. A portion of the infiltrated water, not an inconsiderable one in some cases, is claimed by the subsoil between the level of the drains and the depth to which the water-bed may have sunk below the drains after they have ceased to run in the spring. This space will be found to be more or less according to height and aspect, as influencing gravitation and evaporation, and the extent to which the disintegration of the subsoil by drainage may influence capillary attraction. The quantity discharged by the drains, therefore, does not represent the whole of the infiltrated water, which should be understood to include—(1) the water discharged by the drains; (2) the water which sinks to the springs; and (3) the moisture which rises from the subsoil beneath the drains by attraction into the soil above them, to be dispersed by evaporation at the surface. In many cases, where the surcharged lands approach the lowest outcrop, the drains partake of the nature of perennial springs, and continue to discharge after the higher drains have ceased to run.

When free soils are effectively drained, the water in test-holes between the under-drains will generally stand at an approximate level with

the drains, though its height will fluctuate with the rainfall when any appreciable quantity descends. This being the action of under-draining the surcharged free soils, the results will be, *first*, to render the surface more capable of absorbing the rain that falls upon it; *second*, to lower the discharge of the upper surface springs in a slight degree; and *third*, to withdraw from the power of evaporation all the water which the under-drains discharge, and so add to the river supply.

Discharge from clays.

Before under-draining the "clays," the effect of the autumn rains was to feed their absorbent properties, until the soil was completely saturated to the surface, when the excess would either flow off by the land-furrows and by the slacks and hollows of the natural surface, or it would rest upon the ground until it was dissipated by evaporation. According to the published statements of Mr. Beardmore, the eminent hydraulic engineer, it would appear that the clay lands, in their undrained state, are capable of maintaining certain rivers during the summer; and he shows that 2½ inches of the rainfall are discharged from every contributing acre of the clay soil basin. It is with some diffidence that I venture, upon the strength of my experiments, to express a doubt on this point. The argillaceous soils of this country are so intermixed with the water-bearing strata and drift-beds, that I think it will be found that the supply is derived from interposing free soils, and not from the clays. The water held by an undrained clay is within the reach of evaporation and vegetation, and giving forth moisture to the air, more or less, all the year round; and if Mr. Charnock's Holmfirth experiments are to be relied on, evaporation from a saturated, undrained soil is greater than the rainfall, so that none can go to feed the rivers, except such as passes off the surface when saturated. Mr. Charnock showed by the experiments referred to, that a saturated soil gave off 33 inches, and a drained soil 20 inches, with a rainfall of 26 inches; and although different clays may show different results there will be considerable difficulty in reconciling with this the assumption that in their undrained state they exude (give out) water in support of our rivers equal to the quantity discharged from the under-drains in their drained state, which would appear from Mr. Beardmore's figures to be the case.

Effect of evaporation.

(Note 1883.) [By the Hinxworth experiments (see Vol. XX of the "Journal of the Royal Agricultural Society of England") I found that the drains from the clays did not begin to discharge at all till the end of November. By that time the 3¼ inches of rain which had fallen in October and

November had sufficed to fill the inner pores of the soil, and the drains began to dribble. The results (in abstract) are given by the last column of the following table, by which it will be seen that it was not till January that complete saturation was arrived at. On the 10th of that month, a fall of 0·542 inch, or 12,262 gallons per acre, took place; and the most remarkable increase in the rate of discharge was the consequence. From an outflow of 125 gallons per acre, on the 9th, the outlets discharged 5,150 gallons on the 10th. It is desirable to draw attention to the fact, that it is only when the clays have absorbed their full *quantum* that they will disgorge the rainfall in so large a proportion. In December, when it was observed that the soil below was not full to the level of the drains, the fall of rain on the 13th, of 0·452 inch, or 10,225 gallons per acre, did not affect the discharge in any great degree. The discharge on the 12th was 160 gallons per acre; and it was increased on the 13th to 795 gallons, or six times the amount of the day before. In January, the increase on the 10th was forty-fold. These figures represent the discharge from the clays only. As the character of the subsoil was more open and mixed, this sudden discharge was less. When, therefore, clays, by repeated rains, have had their peculiar property of retention fully satisfied, and hold within them as much, in their drained condition, as they are capable of holding, they are in that state which fits them to discharge the largest proportion of any subsequent rainfall in the shortest time. Any fresh rain taken in above must, then, force out beneath an equal quantity; and as under-drains are aërated conduits, and water is 817 times heavier than air, it can readily be understood that, with a sufficient number of drains to overpower as far as possible capillary attraction, the displacement would be rapid. The very large and sudden discharge from the clays, on occasions of any considerable downfall of rain, is one of the principal points to which it is desirable to give attention, in relation to the arterial channels and outfalls.]

Hinxworth experiments.

The Hinxworth experiments formed the subject of a lengthy discussion, at the Institution of Civil Engineers, in December, 1861. The paper by the writer, upon which the discussion took place, was entitled, "On the Discharge from Under-drainage" (*see Transactions of the Institution, Vol. XXI*); a Telford Medal was awarded to it.

Institution of Civil Engineers.

The writer, at the conclusion of the discussion, said:

"It was not possible to remove surplus water from clays too quickly, but it was quite possible to remove it too rapidly from free soils; in

HINXWORTH DRAINAGE EXPERIMENTS.

MONTHS.	RAINFALL.		QUANTITIES DISCHARGED FROM OUTLETS.				MONTHS.
	Inches.	Per Acre in Gallons.	Free soil from Outlet No. 7, occasional drains. Per acre in gallons.	Mixed soil from Outlet No. 9, occasional drains. Per acre in gallons.	Open clay from Outlet No. 13, wide parallel drains. Per acre in gallons.	Close clay from Outlet No. 15, close parallel drains. Per acre in gallons.	
October	1·645	37,215	12,910	178	9,075	Nil.	October.
November	1·630	36,872	27,000	2,077	6,015	330	November.
December	1·235	27,935	30,135	11,895	16,995	5,825	December.
January	2·333	52,775	43,855	39,090	49,250	31,805	January.
February	·192	4,343	27,360	14,320	13,650	9,060	February.
March	·820	18,547	From Outlet No. 8, at a higher level: 8,415	7,830	5,850	3,310	March.
April	1·440	32,566	From Outlet No. 8, at a higher level: 6,698	10,920	10,530	6,183	April.
May	·750	16,967	From Outlet No. 8, at a higher level: 4,177	5,040	2,775	3,418	May.
Total Rainfall ...	10·045	227,220	160,550	91,350	113,240	59,931	Total discharge per acre.
Difference between Rainfall and Discharge from the drains ...			66,670	135,870	113,980	167,289	
			227,220	227,220	227,220	227,220	Total Rainfall.

fact, the more gradual the action of drainage, so long as the water was kept moving, the better for the land, and the less derangement of the arterial system would be the consequence. This was a point which must some day receive attention from the Engineers of Great Britain, and have its due influence in the mode of under-draining itself.

"It was hardly to be expected otherwise, when it was remembered that, from a sense of economy, the landed interest generally left the control of drainage works on their estates in the hands of bailiffs and superior farm labourers.

"If under-draining was adequately deep, it reduced evaporation, by lowering the water-bed beyond the direct influence of the air, and he had observed that capillary action, when unaffected by evaporation, was greater the deeper the under-drains were placed in the ground, arising from the fact that the interstitial spaces were smaller. If a soil constantly moistened, by capillary action, or otherwise, was subject to full evaporation, it was chilled, and the nearer a soil approached a state of saturation, and the nearer the water-bed came to the surface, the more water it evaporated and the colder it was. The amount of moisture, too, seized by the soil from the atmosphere, is necessarily greater in proportion to the depth of soil aërated.

Effect of under-drainage on river systems

"The effect of draining the clays, as had been generally admitted, was to throw down into the valleys immense quantities of water during the discharging period, which by the Hinxworth tables was shown to last from October to April. This intermittent excess, which affected the rivers, was at the service of engineers if it was properly stored and applied where wanted. The effect of drying the saturated free soils of the country would be to improve—that was, to increase—the perennial supply of water to the rivers by withdrawing from the atmosphere that which the drains discharged in the summer months. Formerly he held the opinion that the effect of under-draining must be to increase the drought of summer; he now withdrew that opinion, on the simple grounds, which his observations and experience had confirmed, that as no water could be discharged from any drains until the soil was filled up to the level of the drains, the subterranean supply could not be diminished, and that whatever water was rescued from the atmosphere was a gain to the rivers during the summer.

"Recurring to the disputed question as to under-drainage increasing the perennial supply, Mr. Denton read a letter from the Premier, Lord Palmerston, of which the following is a copy:—

Letter from Lord Palmerston

"'94, PICCADILLY, *6th January*, 1862.

"'MY DEAR SIR,

"'I have received your letter of to-day. The question to which it relates seems to me to be as clear and as simple as anything can be. It is demonstrable that under-draining must render more dry the atmosphere of the lands drained; and it is equally plain that it cannot materially, if at all, diminish the supply of water to any river that flows through such lands. Undrained land is like a sponge: it is saturated with the moisture which, by capillary attraction, it draws up from below, and, by the moisture which, in certain conditions, such as sea fogs, it

imbibes from the atmosphere, and with the water which falls in the shape of rain or snow. The moisture thus held by this spongy upper stratum of the land is got rid of mainly by evaporation into the atmosphere in contact with such land, and the quantity of water with which that atmosphere is then charged is, in some cases, very considerable, and, being much greater than the air can hold in solution, it is precipitated in the shape of mists and fogs to the detriment of the health of the inhabitants of the district. The effect of sufficient under-draining is to convert four or five or six feet of the upper crust of the land from the condition of a sponge to that of dry earth. That thickness of crust no longer draws moisture from below by capillary attraction, and the water which falls upon it as rain or snow, or which is deposited upon it by sea fogs, instead of rising into the atmosphere by slow evaporation, finds its way rapidly into the drains, and is carried off by them. The soil will however, always, by its retentive nature, keep to itself moisture enough to supply the wants of vegetable roots. The good effects, then, of draining upon the atmosphere of the district drained are demonstrable in theory, and anybody who, like me, has had drained a large extent of land, which before had been very wet, will have amply experienced those good effects in practice. The improvement in the atmosphere of that part of the valley of the Test which extends from a mile above Romsey to two miles or more below it,* is most striking and satisfactory, and is entirely owing to the drainage works which have been executed within those limits. But, then, as to the effect of under-draining upon the supply of water to rivers. Rivers are supplied with water by rivulets which flow into them, and by water which rises from springs in their beds as they flow along. The rivulets will probably be increased in volume by draining works, because they will be made the outfalls for the drainage of land on higher elevations. Then, as to the water, which was before contained in the four or five upper feet of the land through which the river flows,—that water, instead of being evaporated into the atmosphere, is carried along the under-drain, and is delivered into the

(?)

Great improvement of atmosphere from under-drainage.

* The drainage at Broadlands had been executed in 1860–61, in conformity with Mr. Denton's report on the Test Valley, 1853, in which the following remarks were made :—

"As the saturated surface of the valley is constantly presented to the action of the sun and wind, and the peat soil is peculiarly susceptible of capillary action, the amount evaporated will be found to exceed on an average of years the proportion from the porous chalk by at least one-half. Whatever, therefore, is the difference between the evaporation from a constantly wet surface, compared with a drained surface, will represent the loss by evaporation to the miller for power and the irrigator for water, and which neither the one nor the other would perhaps imagine, in the valley of the Test, amounted to 750 tons per annum, from every contributing acre of land.

"But this is not the whole of the miller's loss by the present undrained condition of the valley. It is manifest that the proportion of the rainfall which usually filters through a *porous* soil, and gradually finds its way out again at a lower level, in the present state of the land flows over the saturated surface to the sea as soon as it falls when water is necessarily over abundant. This loss might be in a great measure saved by rendering the surface constantly open and absorbent by drainage, and qualifying it to yield up, for the use of the mills, water which would otherwise never find its way into the stream. It may be fairly assumed that, from these two sources of evaporation and overflow, 12 inches of water over the whole surface of the valley are lost in every year."

river at the earliest point at which the descending level of the river will give a sufficient outfall; and supposing the depth of the drain to be five or six feet, in a river of average rapidity of current, the drained water may be discharged into the river at no very great distance from the beginning of the system of drains. Then, as to the feeding springs which rise up in the beds of rivers, the only water that is withdrawn from them is that which would have been contained in the four or five feet of the upper surface of adjoining lands,—and I have already shown that, as regards such water, the river is a gainer and not a loser by the drainage. All the water in the soil below four or five feet from the upper surface of the land will as before find its way in springs to the beds of the rivers, without being in any way diverted from its course by the drainage of the upper surface. That this has been the case with the Test, I can assert by experience, for the volume of its water has not been in the slightest degree affected by the drainage works in adjoining lands. It has so happened that the river has been much fuller of water during the last two years than it had been for several years before; but that was owing to causes quite unconnected with the drainage works.

"'My dear Sir,

"'Yours faithfully,

(Signed) "'PALMERSTON.'

"'*Bailey Denton, Esq.*'"

The following evidence, given by the author before the Select Committee of the House of Lords on "River Conservancy Boards," is here introduced for the purpose of showing how important a feature in the economy of our water-supply is the under-drainage of land.

"Under-drainage hastens floods, and increases the quantity of water thrown down into the valleys: first, by the improved outfalls which discharge the water of the under-drains as well as such surface waters as flow off the surface, and second, by arresting from the atmosphere that water which in the absence of the under-drains would be evaporated. All land improvement based on systematic drainage effects both those objects at the same time. It is more by these outfall works than by drainage itself that the upland waters, which were previously detained for want of outlet and outfalls, are now thrown down more rapidly into the valleys. Up to the time when the rain has filled the soil and brought it into a state of repletion,—that is, of saturation,—the drained land absorbs and retains the rain falling on its surface, and so retards overflow, and delays floods. When clay land, however, is filled up to a condition of saturation, which generally does not take place much earlier than November, rain falling on the surface will pass through the crust of soil which is drained, down to the under-drains and out by them to an amount equal to one-half of the rainfall in twenty-four hours. If an inch falls on the surface, half an inch when heavy rains occur will pass out by the under-drains.

"*Chairman.* In twenty-four hours?

"In twenty-four hours. This under-drainage water, plus that which flows off the surface when the land is in this saturated condition, amounts to much more than would have escaped off the surface alone before the land was under-drained. Floods are not only hastened, but they are increased, by the quantity of water which the under-drains discharge from beneath the surface, as this water would, before drainage, have been evaporated from the surface. Out of an annual average rainfall of 32 inches experiments made by myself and others have satisfied me that in wet winters as much as 5 inches of rainfall will be absorbed and discharged by clay lands, and twice as much from the under-drains of surcharged free soils, so that if the quantity of hill land under-drained of each description be equal in quantity, the average or mean discharge would be $7\frac{1}{2}$ inches. This water, which is *new water* (inasmuch as before drainage it passed off as vapour into the air), reaches in wet winters in the case of clay lands as much as 113,000 gallons per acre, or upwards of 500 tons per acre in the year; and in cases of free soils as much as 226,000 gallons, or about 1,000 tons of water per acre. This water, which is quite independent of the water which will still flow off the surface when not absorbed, unfortunately reaches its maximum flow at those times when floods prevail."

To fully appreciate the effects of systematic under-drainage on the water economy of the country and the conservancy of our rivers, the two divisions II and III should be considered together.

DIVISION IV (PART 1).

UNDER-DRAINAGE—THE TEACHINGS OF PAST EXPERIENCES.

THE second division of this treatise (the Progress of Under-Drainage in Great Britain) will have satisfied the reader of the magnitude of the object under consideration; for though there may be a difference of opinion as to the perfect accuracy of the figures given, there can be no doubt whatever that the area of wet land remaining undrained extends to many millions of acres, and that the average cost of effecting the drainage will be at least six times as many pounds sterling as there are acres to drain. If this be admitted it may be well to consider (first) the influence of past experiences; (second) the tendency of present opinions; and (third) the prospect for the future. 1883.

The extracts from lectures given and papers read by me from time to time, during the period intervening between the passing of the Public Moneys Drainage Act, 1846, and the present year (1883), will have furnished sufficient particulars of the past to enable the reader to understand the opinions that have prevailed with agriculturists, and to trace the *modus operandi* which has been adopted on estates where the owners have expended their own money, and have exercised their own judgment, without any interference from the Government, as well as that on estates where borrowed capital has been applied, and Government authority has interposed to regulate proceedings.

Why progress of drainage has been slow.

We need not here further discuss details, but it is desirable to answer the very natural inquiry—why the progress of under-drainage has not been as rapid of late years as it was immediately after the passing of the Public Moneys Drainage Act, 1846. The answer is clear. The larger part of the public money (4,000,000*l.* sterling), which was probably hardly sufficient for the drainage of three-quarters of a million acres, was first

applied for and "taken up" by Scotch landowners, who apparently valued highly the privilege of borrowing public money, repayable by instalments at $3\frac{1}{3}$ per cent. and, who therefore lost no time in obtaining their full share of the amount. Though the amount apportioned to England was less rapidly taken up, the extent of land drained up to 1865 was considerable. By that time the capital provided by the several Improvement Companies was gradually taking the place of the public money. Within the same period of time, labour and materials had greatly risen in price, and the work of drainage, which, at starting in 1847, had cost something less than 5*l.* per acre, had reached in 1865 an average of 6*l.* 10*s.* per acre, whilst the capital of the tenant farmer had become less and less, owing to the increased demands made upon him for general and local burdens, and for home and personal expenditure, and had naturally made him less capable, and less inclined, to spend money in those acts of good husbandry which serve to develop good drainage. The result was growing dissatisfaction and reduced expenditure.

Increase of cost.

But independently of this, there is no doubt whatever that the sayings and writings of Smith of Deanston, and Josiah Parkes, raised expectations which could not be realised in practice, without an expenditure which was not fully anticipated and understood, when permanent pipe drainage first came into vogue.

Tenant farmers, with ample means and good judgment, were content with the results they gained from deep drainage combined with deep surface cultivation; but in the case of men with less means of dealing with heavy land and its special requirements it has remained a different matter. With them there seemed to prevail an opinion that under-drainage was to operate in a way to save them expenditure, and in itself to prove a panacea for all the drawbacks imposed by nature upon land of a retentive character. Instead of regarding under-drainage in its proper light—as one of the surest steps that could be taken to secure a profitable return for money spent in judicious husbandry—many occupiers of wet lands considered that they had nothing more to do than to plough as they had ploughed before—3 or 4 inches deep—in all weathers, and to allow their live stock to tread and puddle the surface, to obtain the return the promoters of deep drainage had promised. It need hardly be pointed out that it only required that a succession of wet years (such as the last six or seven years) should follow to bring matters to a climax. Disappointment sooner or later was inevitable

Drainage onl the first step in good husbandry.

and deep under-drainage was blamed for the consequences of the tenant's "failure" to do his duty.

These views were earnestly expressed in the following paper, read at Maidstone in 1872, before the farmers of Mid Kent. I then said:—

Arable land should be laid flat by degrees.

"Under-drainage has been supposed to be a work which, when once executed, requires no help on the part of those who are cultivating the drained land, and that the drains themselves are not liable to any of those casualties which attend the acts of man, though man's best endeavours are but a minimum of defects. These assumptions, more than anything else, have tended to bring drainage into disrepute. Lands laid out in ridges and furrows—the form of *surface* drainage adopted by our forefathers, when they converted our woods and wastes into ploughed fields—are still retained, though wholly inconsistent with *subsoil* drainage, and it must be manifest to every one that so long as the shape of the surface will allow of the rain falling upon it to run from the ridge to the furrow, not only is the latter overloaded with water, and the under-drains placed at a disadvantage, but a system of robbery is going on at the same time, for a large proportion of the manure put on to the ridge is washed by the rain into the furrow, without any capability of turning it to account. It is needless to say that every pains should be taken to reduce the surface to an even condition—not by any rash effort made in one single year, but by degrees, and in several years, until the only furrows that exist shall be those known as 'water furrows,' which are positively necessary to relieve the slacks and hollows formed by nature, and in which water will collect, so long as it retains its property of running to the lowest place. No under-drainage can wholly prevent the collection of water in these hollows, and time must be allowed for its absorption.

Clay lands under the plough should be deeply steam cultivated.

"In the west-midland and midland counties the high-backed lands have been so raised to such a height that two persons standing in different furrows are scarcely able to see each other, while in the eastern counties such a form of surface is hardly known. Still, though the eastern counties have not to contend with such deformities, there exists in them an indisposition with many farmers to take advantage of the facilities at their command, and cultivate deeply. I have often heard men say that with a poor subsoil shallow ploughing is better than deep. There may be some ground for this opinion, but so long as the pan established by ploughings in former generations is maintained by ploughings now equally shallow, the results must be unsatisfactory.

"It is, in point of fact, a *sine quâ non* that the surface soil should be broken up by deep cultivation, and it is lucky for under-drainage that the gradual advance of steam cultivation will annihilate high-backed lands, and force out of practice shallow ploughing, 4 or 5 inches deep. In making these remarks I am not presuming to lay down the law as a farmer, though I have had some experience in that line, but I speak as a constant observer of the acts of other men, and say that every one, without exception, who has adopted *deep cultivation*, extols under-drainage as the foundation of good husbandry, though it is equally true that those who have neglected proper surface treatment complain of its

failure, and will continue to do so as long as the "pan," formed by continual ploughing, remains unbroken.

"'When land is drained no "high-backs" keep,
But lay it flat and plough it deep;
No shallow work, but break the pan
The plough-share made when ploughing began.'
("Doggrel Rhymes," 1868.)

Alleged failures of drainage.

The real cause of dissatisfaction.

"I have had a great many cases brought under my notice, each proclaimed to be a 'failure of drainage,' which, upon examination, I have found to be unsatisfactory owing to causes wholly within the control of the occupying tenants, who have either avoided breaking up this pan, or who have forgotten that drainage does not alter the constituents of clay, but merely its condition, and that it is as wrong to plough and maul land in wet weather after it has been drained, as it was to do so before. No difference in depth will counteract untimely husbandry.

"'Don't force your acts 'gainst nature's will,
Though drain'd the land, 'tis clay land still.
With sun to scorch and wind to dry,
Break up the soil and scarify;
But when your ground is filled with rain
Then your labour is worse than vain,
For each footmark, shod or cloven,
Only stamps the worst of sloven.'
("Doggrel Rhymes," 1868.)

Accidental causes of failure.

Roots of trees.

"The *accidents*, which are beyond the control of both the drainer and the tenant-farmer, are not so readily disposed of. How often have I heard the expression, 'Do you call this drainage?' when water has appeared on the surface of drained land in consequence of the drains being stopped by tree roots, or by the collection of sand, or protoxide of iron in the under-drains. It is impossible to over-estimate the injury arising from these causes. The mischief done to drains by tree roots is very considerable. Within this last month I have known 40*l.* expended in clearing pipes of roots in a property of only 600 acres of heavy clay land. The drainage was executed in the years 1862–3, since which time the tenant has had reason to complain of the want of effect. Had the trees within reach of the drains been removed at the time the drainage was done, all objection might have been avoided, or had the drains been examined as soon as water was seen rising to the surface the evil might have been discovered and removed. As it was, however, the stoppages accumulated until the cost of the remedy reached the amount stated.

Fine sand.

"In sandy districts the drains will at times become filled with sand, particularly where there has been a pressure of water from higher ground, and the sand itself is very minute. No collars nor any other expedients will wholly prevent the influx of sand or the choking of the pipes, where the run of water is variable and small in quantity at times. I have in certain cases prevented the passage of sand into the pipe by wrapping the joints in muslin or calico, but this expedient has not always been attended with success, and I feel bound, therefore, to state, that, in spite of every possible precaution, stoppages will occur, and can only be

remedied by taking up the pipes and clearing them as soon as the evil is suspected. It is wrong to blame the under-drainage.

"In many parts, particularly in Wales, and the mining districts of Cornwall, Lancashire, and Yorkshire, protoxide of iron, locally called 'car,' is very troublesome, and though much good may be done by flushing the drains where there is a command of water, it is and will ever remain a frequent cause of stoppage. There is some consolation, however, in the fact that in the free soils comparatively few drains are required, and therefore the cost of remedy is not very great if the evil be taken in hand in good time. If, on the contrary, it is allowed to accumulate, the land will become quite as bad as it was before drainage. Protoxide of iron.

"Upon large estates all these evils are to be avoided by making a competent man responsible for the maintenance of the whole work, both of drains and outlets. He should be picked out from among those workmen who had been engaged in the drainage when originally executed, and as he would know where to prick for the drains he would be able readily to remove obstructions. This is a practice I universally recommend, and upon an estate of several thousand acres a penny an acre will amply suffice to keep the drainage in proper order, inasmuch as a handy man receiving 15*s.* a week, and devoting five or six weeks in the course of the year upon each thousand acres, would do all that is required. When once this arrangement is established, I find that the tenants are very willing to pay the penny an acre, as they have it in their power, with a map of the drains in their possession, to point out and have rectified at once anything that appears wrong. Every tenant should have hanging up in his room a map of his farm, with every under-drain marked upon it. With small estates, where a man of the sort I have spoken of cannot be retained, it cannot be too strongly impressed upon those who occupy drained lands that to accidental causes and to a lack of proper surface treatment is to be attributed the majority of those consequences which they are too apt to consider defects of drainage. Prevention better than cure. Map of the farm, with under-drains marked on it, necessary.

"While pointing to these serious, but unavoidable, drawbacks, let me point out another source of dissatisfaction. I refer to the stoppage of drains by vermin—such as foxes, rabbits, rats, and mice—which should be provided against, though it not unfrequently happens that gratings at the outlets, if not attended to, cause an evil greater than the one they are intended to remedy. I remember one case, in which fault was found with the execution of the drainage when the cause of stoppage was frogs! It appears that there had been a stream of frogs up a particular drain, and that having met with an obstacle, they had collected one on the other until they had become a compact block, which had the effect, as a matter of course, of stopping the flow. It seems almost childish to refer to such causes of mischief, but you may have observed how little prone all men are to express satisfaction with what they like, when they have to pay for it, though vehement when they think they have any cause for complaint. I am afraid tenant farmers are not exempt from this disposition, and that when their landlords, having drained their farms, require a return on the outlay, they are apt occasionally to find fault with us who carry out the work, without making the same allowance which they would make, as a matter of course, had they executed it themselves. Stoppages caused by vermin.

"But perhaps the most fruitful cause of complaint respecting drainage Neglect of outfalls.

arises from the inattention paid to the clearance of outfall streams and ditches into which the under-drains discharge, and to the maintenance of outlets existing by permission in adjoining properties. It is too frequently the fact that the outlets are not only under water, but that they are blocked by silt, weeds, and other kinds of impediments, which render them at times useless; and it is the obligation to keep the outlets clear of such obstacles, occasionally involving considerable expense, that serves to make deep drainage unpopular. I remember an instance where a tenant on a ducal estate in Lincolnshire, suffering from defective drainage, was unable to show me even the site of his principal outlet, which was intended to discharge the under-drainage water of a large area of land into an important watercourse; and although we looked for it for a long time, I had to leave without seeing it, and I do not know that he has found it to this day. These outfall drawbacks are due to causes partly dependent on the tenant, who is responsible for the clearance of internal ditches, partly to the want of a proper understanding between landlord and tenant with regard to external ditches, which are of common use to several tenants and neighbours, and partly to the want of a ready legal means of clearing common outfalls at the joint expense of those who use them."

Having pointed out the "accidents" to which under-drainage is liable, I can only repeat what I have before stated, that I have *never known a single instance of the failure of under-drainage* where the work has, in the first place, been properly done, and the surface has been deeply cultivated, and in other respects treated at the *proper time.* This fact is important, but my confidence in the soundness of the principle of deep drainage does not rest entirely upon it. It has been greatly fortified by observing the very large increase of production which has rewarded the practice of occupiers who have judiciously developed the remarkable capabilities of deeply drained heavy land upon which many farmers would turn their backs.

Though the principles of deep drainage cannot be fully appreciated without studying the effect and influence of water and air on various soils, as it may be studied in the writings of Josiah Parkes and Professor Way ("Journal of Royal Agricultural Society of England," Vols. V and XVII), of Lyon Playfair ("Encyclopædia of Agriculture," article *Drainage*), of Professor Schubler ("Journal of Royal Agricultural Society of England," Vols. I and XVII), and of Dr. Madden (see "Transactions of the Highland Society," 1846), it may serve a good purpose if, in the spirit of the workman who met his master's quotation of the maxim "*experientia docet,*" by stating that he did not understand any language but his own, but he did know that in most work involving labour "experience does it," I mention some incidents

in my own practice which have very distinctly confirmed theoretical teaching.

Remarkable proof of the success of deep drainage

In the first instance I refer to, I had it in my power (1872) to prove to a tenant farmer, who was not a believer in deep drainage, that he was much too ready to condemn operations which he had not taken the trouble to understand. Some test-holes, which had been dug from 4 to 5 feet deep, had remained full of water (by constant influx) from the beginning of November to the end of January, when there occurred a severe frost. It was just as this frost was breaking, and when the thawing surface presented a wet aspect, that I went over the drainage with him. As we approached one of these holes, he (the tenant), with considerable vivacity, exclaimed, "Look at the water in the test-holes; do you call this drainage?" Expecting from the nature of the soil, which was a marl of the new red sandstone, that there was no water below the ice. I requested my friend to come close to it. I then broke the ice, and found, as I had expected, that the water had escaped to the drains, and left the ice standing, and that upon this ice surface-water had collected in consequence of the thaw. You should have seen how my companion started, and how he stared again and again into the hole when I pressed him to tell me where the water had gone, if the drains, which he had said were of no use, had not taken it away.

The real facts of the case were that the locality (North Cheshire) was subject to more than an average rainfall, and the complainant had never had the patience to wait for the land to free itself of excessive wetness before his ploughmen were at work—puddling it with their ploughshares—and in this particular instance he would not wait for the frost to leave the ground before, in ignorance of what Nature was doing for him below the ice, he condemned the drainage for what appeared above it.

Could any better proof be afforded of the efficacy of 4 feet drains in land which the tenant had declared to be impenetrable, than the emptying of the subsoil of water while the frost prevented the admission of any from above?

Another incident, somewhat more remarkable than this, happened to me, which affords a telling proof of the aëration of clay soils when drained 4 feet deep.

Another proof.

When called in to advise on the drainage of a somewhat extensive property in Somersetshire, it was a part of my duty to meet the several tenants on the estate, and to endeavour, by mutual explanation, to arrange

what lands in their several occupations should be under-drained. When it was pointed out to them (the tenants) that the least depth that would be sanctioned by the Inclosure Commissioners was 4 feet, each declared that he preferred from 2 or 3 feet to 4 feet, and in that manner resisted the wish of the landowner, who, intending to use borrowed capital, was bound to conform to the requirements of the Inclosure Commissioners.

Upon its being explained that there was no option but to conform to the 4 feet, the tenants concurred in having a certain area of flat land in proximity to the sea drained at that depth, as a test of its efficacy. As the work proceeded, they repeatedly observed that the clay was so stiff that no water would get down to the drains. It happened after the work was done, however, that, the tidal flap forming the outlet for the drainage into the sea having been accidentally prevented from closing, the salt water flowed up the main outfall channel, and, entering the main under-drains, travelled up the whole system of minor drains and permeated the soil above the drain for about 3 or 4 inches. Not many days after this occurrence a letter reached me, as the Acting Engineer of the General Land Drainage and Improvement Company, from a local solicitor, asking to whom he should apply for compensation for the injury done to the tenantry by the salt water having caused the death of the numerous worms that had lived in the subsoil (declared to be impenetrable to water and air), and which, having come to the surface to die, were to be seen on the ground from one end to the other. They had turned white, and being uniformly numerous had the appearance of snow from a distance. It was only upon my pointing out how ridiculous the claim would appear if brought into Court, and evidence were given of the views entertained by the tenantry previously to the drainage, that all further action was stayed.

Effect of salt water upon worms 4 feet below surface.

These two striking incidents, though accepted by me as positive proof that both air and water readily penetrate, to the depth of 4 feet, the stiffest clays, will not be so readily accepted, in the same light, by shallow drainers; and the third instance, requiring some scientific knowledge to trace its bearing, will probably be even less convincing. The fact I refer to is that drains—including those 4 feet deep—have been observed to discharge without any rain falling on the surface of the drained land. In the Hinxworth experiments (see "Journal of the Royal Agricultural Society of England," Vol XX) this striking phenomenon is clearly indicated in the table of discharges.

Discharge from under-drains without rain.

Mr. George Beaumont, of Bridgeford Hill, Nottinghamshire, had previously communicated to me the following statement:—

"I can verify the case of the drains running without rain during a falling barometer beyond all doubt.

"The case I named to you last year of the barometer falling four days consecutively, and with rapidity, was a peculiarly favourable time for noticing it, as it occurred in a dry time, and the drains could be seen distinctly. My man, on being questioned and cautioned by me not to exaggerate, has declared the actual stream of water issuing from one particular drain to be as thick as a ⅜-inch wire. All the drains ran—they did more than drop—and ditches which were previously dry became quite wet, with a perceptible stream of water; this gradually ceased with the change in the density of the atmosphere, as shown by the barometer.

"During last harvest, 1855, the men were cutting wheat, and on getting near to a drain outlet, the ditch from the outlet downwards was observed to be wet, and the drain was dripping. No rain fell in sufficient quantity to enter the ground. The men drank of the water while they were cutting the wheat. A few days after it was dry again. I have seen and noticed this phenomenon myself."

Professor Brocklesby, of Hartford, U.S.A., explained the circumstance as due to the "diminished atmospheric pressure which exists before rain," and which, acting upon the water upheld by attraction in the subsoil, induces a discharge by and from the drains laid in that subsoil, showing distinctly not only how freely water and air move in clay soils 4 feet below the surface, but how completely the subsoil at that depth sympathises with the atmosphere. It has been shown by several recorded experiments that the difference of the temperature of soil drained 4 feet deep, compared with undrained soil at the same depth approaches two degrees, which is equivalent to a greatly superior climate.

Two degrees difference of temperature.

These practical proofs of the capability of deep drains to remove water and admit air are not here offered as evidence of the economy of deep drainage; they are given in the hope of removing the belief existing in the minds of those who have not closely studied the matter, that water will not penetrate clay soils, and that therefore shallow drains are better than deep.

Discarding all scientific reasoning the late Sir Robert Peel reduced the matter to a simple question of *money*, which is recurring with great force now that adverse influences have reduced the capital of the tenantry of the country to a minimum. I will therefore add one more incident, which appears to me to be pertinent to this question

of money. When giving evidence in 1873 before the Committee on the Improvement of Land (House of Lords), I was subject to a very close examination by a noble Lord, who was a member of the Committee, and the owner of an estate for which I had long acted as agent during the lifetime of his father. The noble Lord referred to insisted that its drainage was at fault—that, in point of fact, the land had been drained too deeply, &c., &c., because water was seen on the surface of the land after rain. At this time (1873) the rental of the least productive clay land was double what it had been before drainage.

Last year (in 1882), after the recent depression had thrown out of occupation some of the clay lands referred to, there was an inclination to re-drain the portions complained of, and the opinion of an able Inspector of the Inclosure (Land) Commissioners was sought. He met the noble Lord and his agent on the land, when it was discovered—and I believe proved to his Lordship's satisfaction—that, in spite of the water resting in the furrows in times of excessive rainfall, the drainage was not at fault; that in truth the main drains discharged a fair quantity of water, and the lateral drains, which had been laid thirty years, were in a satisfactory condition. He pointed out, however—that which may be readily admitted by every one—that the drains at 36 feet intervals were too far apart. The result of the examination was, I believe, the withdrawal of the intention to re-drain the land, and it is now to be hoped that the money that would have been expended in additional drains will be devoted to deep and appropriate surface cultivation. At the same time it should be understood that if an intermediate drain were introduced, the width suggested by the late Sir Robert Peel—18 feet—would not be exceeded. It is worthy of remark that some of the heavy land on the same estate, having been drained with money borrowed under the Public Moneys Drainage Act, 1846, is already relieved of all charge, and upon a return of better times the noble Lord will have the full benefit of the improvements.

The Inspector in this case, having, with the knowledge of the noble Lord, favoured me with the statement just given, added that "among the large holders of land there are many quietly coming round to the necessity of deep and consequently permanent and efficient drainage," and in confirmation of this remark I have it in my power to state, of my own knowledge, that some of the most intelligent occupiers of clay lands do not hesitate, in face of the change that marks the present state of

opinion, to express their continued confidence in deep drainage; but such men are *deep surface cultivators*, and know that a poached condition of surface may exist immediately over drains, let their depth be what it may; and when at the Covert side they find the ground trodden by hunters into a puddled state, they know well how to account for it, without blaming the drainage.

"Though drained the land 'tis clay land still."

DIVISION IV (PART 2).

UNDER-DRAINAGE—THE PRESENT TENDENCY OF PUBLIC OPINION.

Division of public opinion.

AT the present moment public opinion in relation to under-drainage is divided between *adherence to deep drainage*—by "deep" I mean 4 feet and more—under the conviction that, although the theory of "depth governing distance" has been carried too far where the deep system has not been followed by deep surface cultivation, it will realise for agriculture, in the long run, all that has been expected of it, and *disbelief in the capability of water to pass through drained clay soils*—a disbelief constantly repeated though it is a fact that no land is properly drained that is not aërated to the full depth of the drains, and will not allow of the passage through it of water, which is 817 times heavier than air.

This division of public opinion existing, deep drainers readily admit that with the cost of labour and materials increasing in this country, without the returns of farming keeping pace with the advance, it has become positively necessary, if our clay lands—which, unfortunately, are held, for the most part, by tenants with insufficient capital—are to be drained at all, that a compromise should take place. To secure a satisfactory result the drains must be closer than hitherto, and to meet the question of cost the depth must be reduced to such an extent as may bring the outlay within a fair limit without a sacrifice of safety. It is, however, to be feared that even with the greatest care and foresight these views may lead to greater evils than those that are leading to the compromise, and that we may relapse into shallow drainage with all its evils. This view, expressed in May, 1880, before the Royal Commission on Agriculture, does not differ much from that anticipated in 1854 to the following effect:—"We can well understand the very legitimate doubt that will arise in the minds of deep-draining men as to the expediency of going to the extreme depth in clay soils, upon which in low

times agriculturists are disinclined to embark capital. The practical way of deciding the question of *depth* and *distance* is to be guided by *cost*, irrespective of which there seems to be no hesitation in adopting the greater depth." Such was the opinion of the late Sir Robert Peel (see *ante*, p. 12).

The confidence in deep drainage thus implied when yielding to a reduction of depth on the ground of expediency, is resisted by clay land farmers on the ground—they assert—that water much more quickly descends to drains laid 3 feet deep than to those of 4 feet.

The assertion that water will reach shallow drains in *clay soils* sooner than deep ones, though rational in itself, is not based upon any hydraulic data, nor upon any actual measure of the time that water, absorbed by the surface, will take to gravitate through aërated soil to drains laid at different depths, and overcome, on its way, the friction due to its particles; but it rests on the fact that those who have not capital to expend in the development of deep drainage by opening up the surface soil to let the water pass more freely to the drains, are unwilling to attribute to the right cause the occasional wetness they observe in drained land.

Smith's system regarded with favour.

The owners and tenants of heavy land who are thus led to declare themselves in favour of shallow draining, should not forget that very nearly the last words written by Smith of Deanston, who was regarded as the opponent of deep drainage, were: "I do not so much object to a greater depth than 3 feet as I do to a greater distance between drains in all soils," and that the arrangement, he (Smith) adopted, in consonance with the views he held, was not only to reduce the interval between his drains, which would have been free from objection, but to lessen the depth beyond what would secure freedom from accident to his pipes, and at the same time maintain such a temperature and amelioration of subsoil as would be most productive of vegetation.

Present tendency.

This was Smith's error, nevertheless the tendency of opinion at the present moment is to follow the example of Smith, and to adopt 3 feet drainage (which practically means something less than 3 feet in those hollows and unequal places which exist in all fields), and it is feared that in the large extent of operations which may be opened up by the Settled Land Act, and the Agricultural Holdings Act, shallow draining may become the established rule, and instead of 3 feet drains at such intervals as was suggested by the late Sir Robert Peel—which would be very good drainage if adopted—we shall, before long, revert

to the 18-inch drains, and possibly bushes as well, which were common fifty years back.

Protest against the present disposition to revert to shallow drainage.

It is the belief that such a practice would have a very injurious effect upon the future of agriculture that leads me, at the close of an active life, to express, as forcibly as I can, disapproval of the temporising views which are now being recognised under the influence of respected authority.

These remarks are made in consequence of my attention having been called to a statement which appeared, without any qualification, in an agricultural periodical of considerable influence, edited by an Inspector of the Land Commission—in answer to an inquiry *whether shallow or deep drains in clay lands flowed soonest*—to the effect that it was probable that "the shallow drains of a whole field would run sooner than the deeper drains of another field of a similar character"; which expression has been accepted as the opinion of a Government authority that, as all drainage aimed at the discharge of injurious water as quickly as possible, *shallow drainage was preferable to deep.* Those who have studied the matter in all its bearings, and while approving deep drainage prefer well-executed 3 feet drainage in clay lands to none at all, would have answered the question very differently, inasmuch as *deep clay land drains*, compared with shallow ones, invariably begin to discharge first, discharge more, and continue to discharge longer.

Reason why deep drains run before shallow drains.

The simple reason why deep drains in *clay soils* recommence discharging (after the summer's cessation) before shallow drains is that the subsoil below the level of all drains must be saturated before they discharge. In autumn, the interstitial spaces below the drains will have become comparatively wide, and according to their capacity for holding any water that *descends* to them, so will the recommencement of discharge be delayed.

The influence of the atmosphere is necessarily greater as the drains are shallower. If a piece of wire were passed down the cracks penetrating from the surface in September, it would be found that they would pass the level of the drains, and that the spaces below the level of the 3 feet drains would be larger than those below the 4 feet. If, in fact, they were closely measured the aggregate sectional area of the spaces below the 3 feet would be much more than those below the 4 feet. Hence it follows that rain descending from the surface more quickly fills the subsoil below the deeper drains than that below the shallower drains, and necessarily finds an outlet sooner. Under certain

conditions, the causes assigned by the late Mr. H. S. Thompson, of Yorkshire, for deep drains beginning to run after rain sooner than shallow ones would apply. He said it was due to the elasticity of the air confined between the free water existing above deep drains in clay soils, and that coming in from the top or surface; but the simple action I have endeavoured to describe, as taking place invariably in stiff clay lands, will explain the facts in those cases where there has been a summer's cessation with a renewal of discharge.

DIVISION IV (PART 3).

UNDER-DRAINAGE—THE PROSPECTS OF THE FUTURE.

IN anticipating the future of under-drainage, it may be well to recognise the truth that, although there has been greater progress in agriculture within the last forty years than has signalised any like period in its previous history, the recent succession of wet years has told with even greater severity upon under-drainage than upon any other branch of husbandry, owing to the gradual reduction of the insufficient capital of our heavy land farmers, and their consequent inability to assist in its development.

When Professor Johnston, in his lectures at Durham, declared, forty years back, that we possessed in the clay lands of Great Britain "*if thoroughly drained*," an inexhaustible field for the production of wheat, he did not anticipate that by this date (1883) a very appreciable quantity of those clay lands would be tenantless, owing to the inability of the occupiers to meet the great expenditure involved in heavy land cultivation; and when the writer was advocating the advantage of employing collective capital in the drainage of land, and of giving to rent charges created for the repayment of borrowed capital *priority over existing mortgages*, he little thought that there would come a time when the annual payment of those charges would fall upon the owner in place of the occupier, owing to the lands upon which the rent charges were fixed becoming tenantless. Yet such has been the case. And this is not the worst result to be anticipated from the present state of agriculture in relation to our heavy lands. With the increasing cost of labour and materials, and a decreasing command of tenants' capital, there is good ground for believing that, unless a great effort is made to promote under-drainage and its development by proper after-treatment, a considerable proportion of our clay

lands must go out of cultivation altogether. With a population doubling itself in less than fifty years, whereby fresh markets for agricultural produce are daily arising in our midst, this view would appear incomprehensible, were it not that past experiences favour the possibility. As the cost of manual and horse labour has advanced, agriculturists have regarded steam cultivation as the best, if not the only, means of securing proper surface cultivation, and thereby developing the results from under-drainage to which we have been taught to look forward; but with the diminishing capital of clay land occupiers the application of steam has made but little progress, though in those cases in which it has been resorted to the greatest benefit has resulted. The "cultivator" has been preferred to "the plough," and if the cost of purchasing or hiring a steam cultivator had been within the reach of the majority of tenants there is no doubt whatever that deep drainage would have been much more generally approved, and shallow under-drainage much less frequently advocated.

The preference for steam over horse power, and the preference for the cultivator over the plough, are due to the avoidance (1) of the treading by horses, and (2) of the pressure of the plough-share.

At the present time there seems to be some prospect of the use of another implement, which in itself will be much less costly and much more handy than either the plough or the cultivator; it is known as the "digger." Its chief characteristic is that it travels over the surface it digs, and is self-contained—the engine, boiler, and apparatus for digging being all in one. Moreover, as the rotating spades follow the wheels and raise the ground over which they have passed, the whole surface is completely moved to a greater depth than is reached by the plough. The digger, however, is as yet subject to the very serious objection that, after reducing its weight as much as possible, it is still unmanageable on clay lands under certain conditions of the weather.

But there is a prospect, and a not very distant one, that electricity in a tangible form may take the place of steam as a motor, and then a great reduction may be made, not only in the weight of the travelling implement, but in its cost also, and this may bring it within the reach of the less affluent tenants of heavy lands

In the meantime, while heavy clay lands remain under arable culture stirred by ordinary ploughs only 4 or 5 inches deep, leaving the subsoil to be polished by the share, and while cattle and sheep are allowed to tread and puddle the surface when in a wet state, it would appear that there

is no option but to modify the prevailing practice of under-drainage by reducing the depth of the drains to less than 4 feet, and the interval between them to less than 8 yards. We must, in fact, follow the advice of the late Sir Robert Peel, who, reiterating his preference for deep drainage, said: "I can conceive a case in which if you had a limited sum to expend (say 4*l.* per acre), the nature of the ground might be such that the increased closeness might compensate for diminished depth;—I mean, for instance, that drains 18 feet apart and 3 feet deep might be more effectual than drains 25 feet apart and 4 feet deep. It is utterly untrue that I am dissatisfied with the experiment of deep drainage."

When using these words, Sir Robert Peel felt, as many other deep drainers have felt, and still feel, that, where from a want of means on the part of the tenantry deep cultivation cannot be anticipated, there are conditions when a *greater number of shallow drains may discharge the water falling on the surface more freely than from a fewer number of deep drains;* that, in point of fact, circumstances may exist when expediency would suggest that we should disregard one of the main points aimed at in "*thorough* drainage," *i.e.*, the amelioration of the subsoil and the raising of its temperature to the depth reached by the roots of farm vegetation, and look exclusively to the riddance of surface waters. In doing so, however, it is desirable to avoid the error of believing that water will not descend to a 4 feet drain through a clay soil, because it is (comparatively) deep; for it is found by experience that shallow drains (3 feet deep) are as often attended by a puddled condition of surface as deeper drains.

The question is often asked me, "What is the best means of dealing with the 4 feet drainage that has already been effected? Are additional drains requisite?" My answer is, "Follow up your 4 feet drainage by *deep* surface cultivation, and repeat the practice once in each rotation of cropping!" 4 feet drains, at intervals of 9 yards, with *proper surface treatment*, are more effective—*quâ* the removal of excessive wetness—than 3 feet drains 7 yards apart, *ceteris paribus*. It should always be remembered that the roots of cereals and pulse crops, and the roots of mangels and cabbages, as well as those even of perennial grasses, descend into the earth 4 feet and more, and that there exists no doubt in the minds of all who are not influenced by prejudice that the extra foot of aërated soil will yield a profit on the cost of obtaining it in the shape of superior quantity and quality of produce. In the stiffest clays I

should recommend that a quantity of clay be raised, burnt, and spread on the surface before it is deeply cultivated. This, in many instances, will not need repetition; in others it will. Some excellent papers on the subject of clay burning, by the late Mr. Francis Pym and Mr. Randall, are to be found in the "Journal of the Royal Agricultural Society of England," Vols. III and V.

But perhaps the most important questions that can present themselves to the minds of those who are the owners of heavy clay lands are—(1) whether those lands ought not to be laid down to permanent pasture, and (2) whether with the very sensible decrease (which is repeating itself year after year) in the number of horses, cattle, and sheep produced in this country, associated with increasing cost of manual labour, the return to be obtained from permanent pasture—well laid down—would not, on the whole, be greater than could be obtained from ploughed land, even under ordinary conditions.

The following table will show that, although the numbers of cattle and sheep produced in this country were greater in 1874 than in 1873, the number of each has been gradually diminishing from 1874 to the present year, and that the importation of live stock from foreign lands to meet the decrease has been in correspondence with the diminished supply of this country. In one year only, 1876, the number of sheep imported was more than 100,000 in excess of that of 1881.

Year.	Existing in Great Britain.		Imported.		Year.
	Cattle.	Sheep.	Cattle.	Sheep.	
1873	5,964,549	29,427,635	200,802	851,116	1873
1874	6,125,491	30,313,941	193,862	758,915	1874
1875	6,012,824	29,167,438	263,684	985,652	1875
1876	5,844,141	28,182,951	271,576	1,041,329	1876
1877	5,697,933	28,161,164	201,193	874,055	1877
1878	5,738,128	28,406,206	253,462	892,125	1878
1879	5,856,356	28,157,080	247,768	944,888	1879
1880	5,912,046	26,619,050	389,724	941,121	1880
1881	5,911,642	24,581,053	319,374	935,144	1881
1882	5,807,491	24,319,768	...	...	1882

The deduction to be drawn from studying the two sides of this table certainly encourages the proposal to lay down to permanent pasture any land which is naturally fertile, but which would require a considerable outlay in labour to turn to a profitable account as arable land.

The value of the live cattle and sheep imported into this country last year (8½ millions of pounds sterling) was very nearly double that of the same description of stock imported ten years back (4¼ millions). These are large figures, but they do not approach the increased value of the importations of *butter and cheese*, which in 1881 amounted to 16 million pounds sterling, against 9 million pounds in 1872.

Is there any reason why the clay lands of Huntingdon, Cambridge, Bedfordshire, and Buckinghamshire should not yield a profit in the production of butter and cheese? And, again, is there any sufficient reason why the metropolis should remain without a proper supply of wholesome milk, for which a good price is paid, at a time when a considerable portion of those lands remain under the plough tenantless?

DIVISION V.

BORROWED CAPITAL APPLIED TO LAND DRAINAGE AND OTHER IMPROVEMENTS,

AND THE COURSE TO BE ADOPTED TO OBTAIN IT.

SINCE the passing of the Improvement of Land Act, 1864 (27 and 28 Vict., cap. 114), which was intended by the Legislature to afford to landowners increased facilities for improvements, beyond what they already possessed in the several Improvement Companies' Acts, two important legislative measures have become law, and as they bear on agricultural drainage it may be advantageous at once to show in what way they affect it.

The measures referred to are the Settled Land Act, 1828 (45 and 46 Vict., cap. 38), and the Agricultural Holdings Act, 1883 (47 and 46 Vict., cap. 61). Settled Land Act, 1882, and Agricultural Holdings Act, 1883.

In an article by the writer published in the "Journal of the Royal Agricultural Society of England," Vol. IV, second series, the powers obtained by the different existing improvement companies are explained; but as the Settled Land Act and Agricultural Holdings Act not only comprise all the works those companies had special parliamentary powers to execute, but many additional ones, the most tangible means of showing the present position of matters will be by giving *in extenso* the clauses from both Acts bearing on the subject.

The following are verbatim copies of the clauses referred to.

[*From the Settled Land Act*, 1882.] Settled Land Act, 1882.

"III.—SALE; ENFRANCHISEMENT; EXCHANGE; PARTITION.

"*General Powers and Regulations.*

"A tenant for life—

"(i.) May sell the settled land, or any part thereof, or any easement, Powers to tenant for life to sell, &c.

right, or privilege of any kind, over or in relation to the same; and

"(ii.) Where the settlement comprises a manor,—may sell the seignory of any freehold land within the manor, or the freehold and inheritance of any copyhold or customary land, parcel of the manor, with or without any exception or reservation of all or any mines or minerals, or of any rights or powers relative to mining purposes, so as in every such case to effect an enfranchisement; and

"(iii.) May make an exchange of the settled land, or any part thereof, for other land, including an exchange in consideration of money paid for equality of exchange; and

"(iv.) Where the settlement comprises an undivided share in land, or, under the settlement, the settled land has come to be held in undivided shares,—may concur in making partition of the entirety, including a partition in consideration of money paid for equality of partition.

Regulations respecting sale, enfranchisement, exchange, and partition.

"(1.) Every sale shall be made at the best price that can reasonably be obtained.

"(2.) Every exchange and every partition shall be made for the best consideration in land or in land and money that can reasonably be obtained.

"(3.) A sale may be made in one lot or in several lots, and either by auction or by private contract.

"(4.) On a sale the tenant for life may fix reserve biddings and buy in at an auction.

"(5.) A sale, exchange, or partition may be made subject to any stipulations respecting title, or evidence of title, or other things.

"(6.) On a sale, exchange, or partition, any restriction or reservation with respect to building on or other user of land, or with respect to mines and minerals, or with respect to or for the purpose of the more beneficial working thereof, or with respect to any other thing, may be imposed or reserved and made binding, as far as the law permits, by covenant, condition, or otherwise, on the tenant for life and the settled land, or any part thereof, or on the other party and any land sold or given in exchange or on partition to him.

"(7.) An enfranchisement may be made with or without a re-grant of any right of common or other right, easement, or privilege theretofore appendant or appurtenant to or held or enjoyed with the land enfranchised, or reputed so to be.

"(8.) Settled land in England shall not be given in exchange for land out of England."

"V.—SALES, LEASES, AND OTHER DISPOSITIONS.

"*Mansion and Park.**

Restriction as to mansion house, park, &c.

"Notwithstanding anything in this Act, the principal mansion house on any settled land, and the demesnes thereof, and other lands usually

* The owners of settled estates will find "The Limited Owners' Residences Act a valuable measure in assisting them in obtaining money for extensions to their mansions or additions to the curtilage thereof.

occupied therewith, shall not be sold or leased by the tenant for life, without the consent of the trustees of the settlement, or an order of the Court."

"INVESTMENT OR OTHER APPLICATION OF CAPITAL TRUST MONEY.

Capital money under Act; investment, &c., by trustees or Court.

"Capital money arising under this Act, subject to payment of claims properly payable thereout, and to application thereof for any special authorised object for which the same was raised, shall, when received, be invested or otherwise applied wholly in one, or partly in one and partly in another or others, of the following modes (namely):

"(i.) In investment on Government securities, or on other securities on which the trustees of the settlement are by the settlement or by law authorised to invest trust money of the settlement, or on the security of the bonds, mortgages, or debentures, or in the purchase of the debenture stock, of any railway company in Great Britain or Ireland incorporated by special Act of Parliament, and having for ten years next before the date of investment paid a dividend on its ordinary stock or shares, with power to vary the investment into or for any other such securities:

"(ii.) In discharge, purchase, or redemption of incumbrances affecting the inheritance of the settled land, or other the whole estate the subject of the settlement, or of land-tax, rent-charge in lieu of tithe, Crown rent, chief rent, or quit rent, chargep on or payable out of the settled land:

"(iii.) *In payment for any improvement authorised by this Act:*

"(iv.) In payment for equality of exchange or partition of settled land:

"(v.) In purchase of the seignory of any part of the settled land, being freehold land, or in purchase of the fee simple of any part of the settled land, being copyhold or customary land:

"(vi.) In purchase of the reversion or freehold in fee of any part of the settled land, being leasehold land held for years, or life, or years determinable on life:

"(vii.) In purchase of land in fee simple, or of copyhold or customary land, or of leasehold land held for sixty years or more unexpired at the time of purchase, subject or not to any exception or reservation of or in respect of mines or minerals therein, or of or in respect of rights or powers relative to the working of mines or minerals therein, or in other land:

"(viii.) In purchase, either in fee simple, or for a term of sixty years or more, of mines and minerals convenient to be held or worked with the settled land, or of any easement, right or privilege convenient to be held with the settled land for mining or other purposes:

"(ix.) In payment to any person becoming absolutely entitled or empowered to give an absolute discharge:

"(x.) In payment of costs, charges, and expenses of or incidental

to the exercise of any of the powers, or the execution of any of the provisions, of this Act:

"(xi.) In any other mode in which money produced by the exercise of a power of sale in the settlement is applicable thereunder."

"VII.—IMPROVEMENTS.

"*Improvements with Capital Trust Money.*

Description of improvements authorised by Act.

"Improvements authorised by this Act are the making or execution on, or in connexion with, and for the benefit of settled land, of any of the following works, or of any works for any of the following purposes, and any operation incident to or necessary or proper in the execution of any of those works, or necessary or proper for carrying into effect any of those purposes, or for securing the full benefit of any of those works or purposes (namely):

"(i.) Drainage, including the straightening, widening, or deepening of drains, streams, and watercourses:

"(ii.) Irrigation; warping:

"(iii.) Drains, pipes, and machinery for supply and distribution of sewage as manure:

"(iv.) Embanking or weiring from a river or lake, or from the sea, or a tidal water:

"(v.) Groynes; sea walls; defences against water;

"(vi.) Inclosing; straightening of fences; re-division of fields:

"(vii.) Reclamation; dry warping:

"(viii.) Farm roads; private roads; roads or streets in villages or towns:

"(ix.) Clearing; trenching; planting:

"(x.) Cottages for labourers, farm-servants, and artisans, employed on the settled land or not:

"(xi.) Farmhouses, offices, and out-buildings, and other buildings for farm purposes:

"(xii.) Saw-mills, scutch-mills, and other mills, water-wheels, engine-houses, and kilns, which will increase the value of the settled land for agricultural purposes or as woodland or otherwise:

"(xiii.) Reservoirs, tanks, conduits, watercourses, pipes, wells, ponds, shafts, dams, weirs, sluices, and other works and machinery for supply and distribution of water for agricultural, manufacturing, or other purposes, or for domestic or other consumption:

"(xiv.) Tramways; railways; canals; docks:

"(xv.) Jetties, piers, and landing places on rivers, lakes, the sea, or tidal waters, for facilitating transport of persons and of agricultural stock and produce, and of manure and other things required for agricultural purposes, and of minerals, and of things required for mining purposes:

"(xvi.) Markets and market-places:

"(xvii.) Streets, roads, paths, squares, gardens, or other open spaces for the use, gratuitously or on payment, of the public or of

individuals, or for dedication to the public, the same being necessary or proper in connexion with the conversion of land into building land:

"(xviii.) Sewers, drains, watercourses, pipe-making, fencing, paving, brick-making, tile-making, and other works necessary or proper in connexion with any of the objects aforesaid:

"(xix.) Trial pits for mines, and other preliminary works necessary or proper in connexion with development of mines:

"(xx.) Reconstruction, enlargement, or improvement of any of those works.

Approval by Land Commissioners of scheme for improvement and payment thereon.

"(1.) Where the tenant for life is desirous that capital money arising under this Act shall be applied in or towards payment for an improvement authorised by this Act, he may submit for approval to the trustees of the settlement, or to the Court, as the case may require, a scheme for the execution of the improvement, showing the proposed expenditure thereon.

"(2.) Where the capital money to be expended is in the hands of trustees, then, after a scheme is approved by them, the trustees may apply that money in or towards payment for the whole or part of any work or operation comprised in the improvement, on—

"(i.) A certificate of the Land Commissioners certifying that the work or operation, or some specified part thereof, has been properly executed, and what amount is properly payable by the trustees in respect thereof, which certificate shall be conclusive in favour of the trustees as an authority and discharge for any payment made by them in pursuance thereof; or on

"(ii.) A like certificate of a competent engineer or able practical surveyor nominated by the trustees and approved by the Commissioners, or by the Court, which certificate shall be conclusive as aforesaid; or on

"(iii.) An order of the Court directing or authorising the trustees to so apply a specified portion of the capital money.

"(3.) Where the capital money to be expended is in Court, then, after a scheme is approved by the Court, the Court may, if it thinks fit, on a report or certificate of the Commissioners, or of a competent engineer or able practical surveyor, approved by the Court, or on such other evidence as the Court thinks sufficient, make such order and give such directions as it thinks fit for the application of that money, or any part thereof, in or towards payment for the whole or part of any work or operation comprised in the improvement."

"*Improvement of Land Act*, 1864.

Extension of 27 & 28 Vict., c. 114, s. 9.

"The enumeration of improvements contained in section nine of the Improvement of Land Act, 1864, is hereby extended so as to comprise, subject and according to the provisions of that Act, but only as regards applications made to the Land Commissioners after the commencement of this Act, all improvements authorised by this Act."

"CONTRACTS.

Power for tenant for life to enter into contracts.

"(1.) A tenant for life—

"(i.) May contract to make any sale, exchange, partition, mortgage, or charge; and

"(ii.) May vary or rescind, with or without consideration, the contract, in the like cases and manner in which, if he were absolute owner of the settled land, he might lawfully vary or rescind the same, but so that the contract as varied be in conformity with this Act; and any such consideration, if paid in money, shall be capital money arising under this Act; and

"(iii.) May contract to make any lease; and in making the lease may vary the terms, with or without consideration, but so that the lease be in conformity with this Act; and

"(iv.) May accept a surrender of a contract for a lease, in like manner and on the like terms in and on which he might accept a surrender of a lease; and thereupon may make a new or other contract, or new or other contracts, for or relative to a lease or leases, in like manner and on the like terms in and on which he might make a new or other lease, or new or other leases, where a lease had been granted; and

"(v.) May enter into a contract for or relating to the execution of any improvement authorised by this Act, and may vary or rescind the same; and

"(vi.) May, in any other case, enter into a contract to do any act for carrying into effect any of the purposes of this Act, and may vary or rescind the same.

"(2.) Every contract shall be binding on and shall enure for the benefit of the settled land, and shall be enforceable against and by every successor in title for the time being of the tenant for life, and may be carried into effect by any such successor; but so that it may be varied or rescinded by any such successor, in the like case and manner, if any, as if it had been made by himself.

"(3.) The Court may, on the application of the tenant for life, or of any such successor, or of any person interested in any contract, give directions respecting the enforcing, carrying into effect, varying, or rescinding thereof.

"(4.) Any preliminary contract under this Act for or relating to a lease shall not form part of the title or evidence of the title of any person to the lease, or to the benefit thereof."

Agricultural Holdings Act, 1883.

[*From the Agricultural Holdings Act*, 1883.]

"IMPROVEMENTS.

"*Compensation for Improvements.*

General right of tenant to compensation.

"Subject as in this Act mentioned, where a tenant has made on his holding any improvement comprised in the First Schedule hereto, he shall, on and after the commencement of this Act, be entitled on quitting his holding at the determination of a tenancy to obtain from the land-

lord, as compensation under this Act for such improvement, such sum as fairly represents the value of the improvement to an incoming tenant: Provided always, that in estimating the value of any improvement in the First Schedule hereto, there shall not be taken into account as part of the improvement made by the tenant what is justly due to the inherent capabilities of the soil."

"As to Improvements executed before the Commencement of Act.

"Where a tenant has executed an improvement mentioned in the first or second part (Drainage) of the said First Schedule within ten years previous to the commencement of this Act, and he is not entitled under any contract, or custom, or under the Agricultural Holdings (England) Act, 1875, to compensation in respect of such improvement, and the landlord, within one year after the commencement of this Act, declares in writing his consent to the making of such improvement, then such tenant on quitting his holding at the determination of a tenancy after the commencement of this Act may claim compensation under this Act in respect of such improvement in the same manner as if this Act had been in force at the time of the execution of such improvement."

"As to Improvements executed after the Commencement of Act.

Notice to landlord as to improvement in First Schedule, Part II.

"Compensation under this Act shall not be payable in respect of any improvement mentioned in the second part of the First Schedule hereto (Drainage), and executed after the commencement of this Act, unless the tenant has, not more than three months and not less than two months before beginning to execute such improvement, given to the landlord, or his agent duly authorised in that behalf, notice in writing of his intention so to do, and of the manner in which he proposes to do the intended work; and upon such notice being given the landlord and tenant may agree on the terms as to compensation or otherwise on which the improvement is to be executed; and in the event of any such agreement being made, any compensation payable thereunder shall be deemed to be substituted for compensation under this Act, or the landlord may, unless the notice of the tenant is previously withdrawn, undertake to execute the improvement himself, and may execute the same in any reasonable and proper manner which he thinks fit, and charge the tenant with a sum not exceeding five pounds per centum per annum on the outlay incurred in executing the improvement, or not exceeding such annual sum payable for a period of twenty-five years as will repay such outlay in the said period, with interest at the rate of three per centum per annum, such annual sum to be recoverable as rent. In default of any such agreement or undertaking, and also in the event of the landlord failing to comply with his undertaking within a reasonable time, the tenant may execute the improvement himself, and shall in respect thereof be entitled to compensation under this Act.

"The landlord and tenant may, if they think fit, dispense with any notice under this section, and come to an agreement in a lease or otherwise between themselves in the same manner and of the same validity as if such notice had been given."

"Procedure.

Notice of intended calim.

"A tenant claiming compensation under this Act shall, two months at least before the determination of the tenancy, give notice in writing to the landlord of his intention to make such claim."

Compensation agreed or settled by reference.

"The landlord and the tenant may agree on the amount and mode and time of payment of compensation to be paid nnder this Act.

"If in any case they do not so agree the difference shall be settled by a reference."

"Charge of Tenant's Compensation.

Power for landlord on paying compensation to obtain charge.

"A landlord, on paying to the tenant the amount due to him in respect of compensation under this Act, or in respect of compensation authorised by this Act to be substituted for compensation under this Act, or on expending such amount as may be necessary to execute an improvement under the second part of the First Schedule hereto, after notice given by the tenant of his intention to execute such improvement in accordance with this Act, shall be entitled to obtain from the county court a charge on the holding, or any part thereof, to the amount of the sum so paid or expended.

"The court shall, on proof of the payment or expenditure, and on being satisfied of the observance in good faith by the parties of the conditions imposed by this Act, make an order charging the holding, or any part thereof, with repayment of the amount paid or expended, with such interest, and by such instalments, and with such directions for giving effect to the charge, as the court thinks fit.

"But, where the landlord obtaining the charge is not absolute owner of the holding for his own benefit, no instalment or interest shall be made payable after the time when the improvement in respect whereof compensation is paid will, where an award has been made, be taken to have been exhausted according to the declaration of the award, and in any other case after the time when any such improvement will in the opinion of the court, after hearing such evidence (if any) as it thinks expedient, have become exhausted.

"The instalments and interest shall be charged in favour of the landlord, his executors, administrators, and assigns."

Advance made by a company.

"Any company now or hereafter incorporated by Parliament, and having power to advance money for the improvement of land, may take an assignment of any charge made by a county court under the provisions of this Act, upon such terms and conditions as may be agreed upon between such company and the person entitled to such charge; and such company may assign any charge so acquired by them to any person or persons whomsoever."

It will be seen that in the Agricultural Holdings Act, 1883, the work of drainage is made a special feature,—Part II of the First Schedule being devoted to drainage. The clauses extracted from the Act and given verbatim here will be found so difficult of application, and so likely, if acted upon, to lead to litigation, that it is most desirable that both

landlords and tenants should understand how far existing Acts will help them to effect the intentions of the Legislature without the difficulties here anticipated. The extract from the article referred to, which follows, will show how far the several Drainage and Improvement Companies can assist landowners and tenant farmers in the execution of drainage works.

The obligation imposed on landlords under the Agricultural Holdings Act, either to execute drainage works at the instance of their tenants although the latter may not pay more than 5 per cent. on the outlay, or to submit to the tenants doing the work themselves, will compel the owners of wet land still remaining undrained to consider whether the terms imposed by that Act do not preclude them from executing any drainage works under it. By Section IV (*see ante*) the landlord may agree with the tenant on the terms upon which the improvement is to be executed, "or he may undertake to execute the improvement himself" and charge the tenant an annual sum not exceeding 5 per cent. on the outlay incurred, or not exceeding such annual sum payable for a period of 25 years as will repay such outlay in the said period with interest at the rate of 3 per cent. per annum." In nine of ten cases where drainage is carried out under the Act, the landlord will take it upon himself, and it will involve a loss to him of 14*s.* 10¼*d.* per annum upon every 100*l.* expended (if he can borrow the money at 3 per cent., which is very improbable), inasmuch as the annual instalment to repay 100*l.* in 25 years at 3 per cent. amounts to 5*l.* 14*s.* 10¼*d.* Speaking from a knowledge of the terms upon which the General Land Drainage and Improvement Company advance money to landowners it is satisfactory to be able to state that the rate charged to repay 100*l.* in 31 years is 5*l.* 13*s.* 2*d.*, or 1*s.* 8¾*d.* less than the 5*l.* 14*s.* 10¼*d.* chargeable under the Agricultural Holdings Act; the only disadvantage being that the term for repayment, instead of being limited to 25 years, extends to 31 years. The General Land Drainage and Improvement Company have advanced upwards of 2½ millions sterling repayable in 31 years, with the rate of instalment varying from 5*l.* 13*s.* 2*d.* but slightly. The attention of the reader is directed to the tabular statements appended to this treatise. They will show him, in the most practical form, the costs incurred by a landowner when resorting for money to the Company referred to.

General Land Drainage and Improvement Company's rate £5 13*s.* 2*d.*

Reprint of portions of a Prize Essay by the writer, from the "Journal of the Royal Agricultural Society of England," Vol. IV, Second Series, Part I, 1868.

Original paper, 1868.

"The first effort made to apply collective capital to the improvement of landed property was that made in the year 1843, by the Yorkshire Land Drainage Company, of which Mr. J. H. Charnock, of Wakefield, was the originator, and in which the late Earl of Carlisle was Chairman, with a Board of Directors, of which the late Mr. James Smith, of Deanston, and the present writer formed part. The Yorkshire Company, however, did not succeed in establishing itself, owing to the difficulties started by mortgagees and other claimants having interest in entailed estates; but it did great service in originating a Bill for the extension of legislative powers to overcome these difficulties, which the late Mr. Philip Pusey, in the session of 1844, undertook to conduct through the House of Commons.

"This Bill, which was first sketched out, and submitted to Mr. Bellenden Ker, the eminent draftsman, by the writer, was intended to secure a more direct and less costly means of proceeding than that laid down by Mr. Pusey's Act of the 3 and 4 Vict., and to obtain for drainage loans *priority over existing mortgages*, on the ground that as no loan for that purpose would be sanctioned unless it could be satisfactorily shown that the return from the improvement would exceed in annual amount the rent-charge by which the cost would be repaid, the security of existing mortgages was enhanced and not diminished.

"On the 7th of January, 1844, Mr. Pusey wrote to the writer:—'The question of amending my Act has certainly now become more practicable, as well by the formation of the Yorkshire Society as by the lapse of time, and by your having obtained from Mr. Bellenden Ker positive suggestions on the subject. All these suggestions, as far as I can understand them, appear to me improvements, and *I should even be disposed to try priority for such charges over existing mortgages.*'*

First acceptance by Parliament of the principle of charging estates with the cost of improvements in priority of existing moneys.

* The following copy of a letter, written by the late Mr. Pusey to the writer, will be read with interest:—

"DEAR SIR, "PUSEY, *August* 3, 1844.

"I am sorry that as the Solicitor-General disapproved of your Bill, it becomes hopeless to carry it beyond a second reading. I doubt if we can gain the point of priority. If the parties whom you represent think it desirable to proceed, your best course would be to draw up a statement of existing difficulties, and the proposed remedies. [*This was done—See Appendix to the Report of the (late) Duke of Richmond's Committee.*] The Duke of Richmond has expressed his readiness to assist us, and I would communicate your representation to him. Possibly, as it relates to

"It was at this time that the Prime Minister, the late Sir Robert Peel, considered it due to the agricultural interest that an advance of public money should be made for the drainage of land, in order that the owners of settled estates might be the better able to meet any depreciating effects which might follow the repeal of the Corn Laws.

Public Moneys Drainage Acts and its advantages.

"The Public Moneys Drainage Act (9 and 10 Vict., cap. 101) was the result of this concession.

"The advantages it embraced were, first, the removal of the proceedings out of the hands of the Master in Chancery, where Mr. Pusey's Act had left them, into those of the Inclosure Commissioners; next, the precedence given to improvement charges over existing mortgages, which, having been adopted in spite of the Solicitor-General's disapproval, has done more for agricultural progress than any step previously taken in relation to settled estates; and last, the foundation of a system of drainage which, though open to some objections, has, on the whole, acted wholesomely and beneficially for the advancement of agriculture.

"While capitalists were busy in the establishment of private companies as a medium of supplying money for land improvements, a general Act was passed, called, The Private Moneys Drainage Act, 1849 (12 and 13 Vict., cap. 100), the object of which was to promote the application of private money to the same purposes, and upon the same principles and machinery of action, as had operated in the Public Money Act.

Private Moneys Drainage Act since repealed.

"The term of years for which landowners could charge their estates for the repayment of loans was the same under both Acts, namely, twenty-two years; but the great boon conceded by the use of the public money at a low rate of interest became manifest directly an effort was made to effect a private loan repayable in that period of years.

"In Clause 34 of the Public Money Act it was enacted that the land improved should be charged 'with the payment to Her Majesty in respect of such advance of a rent-charge after the rate of 6*l.* 10*s.* rent for every 100*l.* of such advance.'

£6 10*s.* per annum for 22 years.

"In Clause 9 of the Private Money Act it was enacted that the Inclosure Commissioners should issue a grant of rent-charge 'to be payable by half-yearly payments for and during the term of twenty-two years,' leaving the landowner to arrange with any capitalist lending the

proceedings in Chancery, it would be best that the Bill should be originated in the House of Lords, where there are so many who have been at the head of that court.

"January next, however, will be soon enough for you to put me in possession of your views.

"Yours very truly,

"J. Bailey Denton, Esq." "PHILIP PUSEY.

money, the rate of interest he should pay for the same not exceeding 5 per cent., which under Clause 4 of the Act was the utmost rate of interest the Inclosure Commissioners could sanction.

"It was soon found that private capitalists could not advance money, at the same rate of interest—viz., 3⅓ per cent.—as the Government were able to do, and that as the rate of interest they demanded in a great measure corresponded with the *fluctuating* value of money in the open market, the annual instalment exceeded the amount tenants were prepared to pay for drainage. This will be seen when it is pointed out that the annual instalment to repay 100*l.* with interest at 4½ per cent. was 7*l.* 5*s.*, and at 5 per cent. 7*l.* 10*s.*, instead of 6*l.* 10*s.* with which the Government were satisfied.

"This, however, was not the only reason why little was done under The Private Moneys Drainage Act, 1849. Capitalists generally objected to advance money repayable by instalments, on the ground that they were unable to re-invest without loss the portions of principal money when repaid, and that where the half-yearly payments were small the arrangement altogether ceased to be mutually advantageous. Insurance Offices, however, do not entertain the same objections, but they have preferred dealing with companies under their special Acts, rather than individual owners under a general Act.

Various Companies' Acts.

"It was to supply the place of the Public Moneys Drainage Act that the various companies were established under their special Acts of Parliament, by which they were enabled to transfer the rent-charges created under their Acts in such aggregate amounts as would be acceptable to corporate institutions (Insurance Companies) whose arrangements admitted of their dealing with them. By this power they severally gained the command of unlimited capital.

"The earliest Act now in force is that of the General Land Drainage and Improvement Company, 1849, by which powers were given to charge the cost of the more permanent improvements, such as drainage, clearing, and inclosing land for the term of fifty years, and for the erection of farmhouses and farm buildings for the term of thirty-one years. The fifty years' term has been but seldom adopted, though, if land owners find their own money and spend it in the improvement of property entailed upon one child, and then take a charge in favour of other children, it would seem to be pre-eminently right to make the charge fifty years, or as long as the probable life of those children.

"The two Companies' Acts (England) which have since been obtained

—*i.e.*, the Lands Improvement Company's Acts and the Land Loan and Enfranchisement Company's Act—do not contain the power to charge for even as long a term as the less period (thirty-one years) to which the General Land Drainage and Improvement Company have become limited in practice, and the Irish and Scotch Acts are subject to the same restriction.

"The features which distinguish the three English companies may be shortly stated as follows:—

Distinguishing features of each company.

"The General Land Drainage and Improvement Company either executes works on commission for landowners, or advances capital to landowners who desire to execute their works themselves. This Company finds favour with limited owners who desire to be free from responsibility, with agents who consider that special works like drainage should be executed by specialists, and with tenant farmers after they have realised the true objects of the Company.

"The Lands Improvement Company, and the Land Loan Company, act only as a medium of supplying capital to landowners who may desire to execute their works themselves, while the Inclosure Commissioners control the proceedings equally of all the companies where the outlay is to be charged on the lands improved.

"Besides the several Acts already referred to there is the general Act of the 27 and 28 Vict., cap. 114, entitled, The Improvement of Land Act, 1864, which was intended to include all the powers of the several companies. In fact, when enumerating the objects covered by the term 'Improvement of Land,' all the works specified in the various private Acts are repeated. It goes, in fact, somewhat further, and includes in its provisions one of the most important privileges which has yet been granted to landowners with limited interests. It enables them to subscribe to railways and canals, the construction of which may benefit their estates, if the Land Commissioners approve of the object.

Improvement of Land Act, 1864.

"But it cannot be withheld from the agricultural interest, that however desirable it may be to have at command such general powers as were gained by the Improvement of Land Act, 1864, the same difficulty of securing money under its provisions now prevails, and will continue to prevail, as attended the Private Moneys Drainage Act—which it repealed—although the period for the repayment of borrowed money has been extended from twenty-two to twenty-five years. The medium of supply will still be wanted. Moreover, nothing can be

done under a general Act without recourse to legal assistance, which is altogether avoided with the companies.

Drainage a landlord's duty.

Original paper, 1872.

"I will conclude by referring to a point in connection with the cost of labour which has had its share in deferring the execution of drainage works—I mean the indisposition of tenant farmers to give up to their landlords the carrying out of drainage operations. It may be particularly opportune when taking action under the Agricultural Holdings Act. 'Many tenants prefer to pay for the labour and do the work themselves, if the landlord will find the materials, and at first blush this appears to be a very equitable arrangement; on examination, however, it has nothing to recommend it, either to the landlord, who would thus pay two-fifths of the cost, or to the tenant, who would pay the remaining three-fifths. To the landlord it is objectionable, because he would be paying his share without any return whatever during the occupation of the tenant paying for the labour, though he would not fail to recoup himself upon the retaking of the farm, or a fresh tenancy occurring. To the tenant farmer, who may flatter himself that he is making a good bargain, the arrangement has even less to recommend it. This will be seen by dissecting the figures. The average length of holdings in this county has, I believe, been shown to be fourteen years, taking into consideration change of occupation resulting from death and other causes. The average cost of 4 feet clay land drainage may be taken to be at this moment 6*l.* an acre, of which 3*l.* 12*s.* would represent the cost of the labour (which the tenant would pay), and 2*l.* 8*s.* the value of the materials (supplied by the landlord). If we suppose 100 acres to be drained on this arrangement, the amount of money contributed by the tenant would be 360*l.*, and that by the landlord 240*l.* It is unnecessary to point out that the tenant might employ his 360*l.* on the farm in the purchase of stock or manure, and, if properly used, might gain from it a return of at least 10 per cent., which is 36*l.* a year. If he had capital enough without it, he could lend the money on good security, through his lawyer, and get 5 per cent. for it, or 18*l.* a year. In each case he would retain the principal money for the benefit of his family when he should die. Now let us suppose that he buries the 360*l.* in the drainage of his farm. To recover the outlay in the average length of tenancies (fourteen years)—which he must do if he acts justly to himself and children—with 10 per cent. interest, which I have shown he could gain by another use of the money, he must make as profit

Proof that it is not economical for tenants to pay for the labour whilst the landlord pays for materials.

rather over 16 per cent., or between 57*l.* and 58*l.* a year, which is 11*s.* 6*d.* an acre. The principal money would then come back to him by driblets, and, if not re-invested each year of the fifteen years, which would be a rather difficult thing to do, would very probably have vanished by the end of the fourteenth year. Compare this state of things with the landlord executing the whole of the drainage when the cost of the work, with interest, would be charged on the drained lands, and repaid by instalments. You will find that a tenant being required to discharge the whole charge, would have to pay within a fraction 33*l.* 10*s.* a year for the 100 acres, or 6*l.* 12*s.* an acre. By use of a company the landlord would save his contribution, while the tenant would pay only two-thirds of what he would contribute under the other arrangement. He would, moreover, have his principal money to lay out in any way he pleased; and, supposing he put it out on mortgage, he would have 18*l.* a year interest coming in towards the annual payment of 33*l.* 10*s.*"—*From a lecture given by the writer at Maidstone*, 1872.

These last observations should be well digested by tenants disposed to drain the wet lands of their farms under the Agricultural Holdings Act, 1883.

APPENDIX.

COPY OF A PAPER PLACED BEFORE THE SELECT COMMITTEE ON THE IMPROVEMENT OF LAND, ON THE 6TH MAY, 1873, SHOWING THE COMMISSION OF THE GENERAL LAND DRAINAGE AND IMPROVEMENT COMPANY, AND THE FEES OF THE GOVERNMENT UNDER THE THREE DIFFERENT CLASSES OF PROCEEDINGS.

Where Works are Executed by the Company.

Number of Contract.	Name of Landowner.	Character of Works.	Outlay in works, including Architect or Engineer.	Company's Commission.	Inclosure Commissioners' Expenses and Payments for Stamp Duty, &c.	Total.
			£ s. d.	£ s. d.	£ s. d.	£ s. d.
48	Robert Clutterbuck.	Drainage and roads.	4,153 5 0	229 5 0	38 9 6	4,420 19 6
406	H. E. C. Ker Seymer.	Drainage and buildings.	3,116 10 0	182 5 0	60 19 10	3,359 15 0
142	Edward Bennett...	Drainage and buildings.	7,746 6 10	397 12 6	145 14 9	8,289 14 1
			15,016 2 0	809 2 6	245 4 1	16,070 8 7
				= £5 8s. per cent.	= £1 12s. 8d. per cent.	
				= Together £7 0s. 8d.		

Where Works are Executed by Landowners.

270	Lady Barker Mill	Drainage, buildings, &c.	4,979 0 2	290 2 1	50 7 2	5,319 9 5
273	Sir R. T. Gerard	Drainage, cottages, roads, &c.	3,845 19 10	211 10 7	52 19 7	4,110 10 0
352	Lord St. John ...	Buildings and enclosing.	1,800 0 0	99 0 0	75 0 0	1,974 0 0
354	The Duke of Rutland.	Cottages	1,920 0 0	105 12 0	53 14 0	2,079 6 0
373	The Duke of Rutland.	Cottages	1,622 3 6	84 3 8	44 6 10	1,750 14 0
			14,167 3 6	790 8 4	276 7 7	15,233 19 5
				= £5 11s. 6d. per cent.	= £1 18s. 7d. per cent.	
				= Together £7 10s. 1d.		

Where Works are Executed by Landowners under Special Arrangements.

355	The Earl of Pembroke.	Buildings, cottages, &c.	34,848 9 8	1,219 13 11	404 6 5	36,472 10 0
356	The Marquis of Ailesbury.	Drainage, buildings, roads, &c.	12,384 11 0	431 14 6	173 14 6	12,990 0 0
			47,233 0 8	1,651 8 5	578 0 11	49,462 10 0
				= £3 10s. per cent.	= £1 4s. 6d. per cent.	
				= Together £4 14s. 6d.		

The General Land Drainage and Improvement Company.

STATEMENT showing the fluctuating character of the business undertaken by the Company. The period taken is 15 years. The Company was established by Act of Parliament in 1849.

	Amount of Applications.		Total of each year's Expenditure.
	Where the Landowner executed the works by his own Agent. Class I.	Where the Company executed the works for the Landowner. Class IV.	
	£ s. d.	£ s. d.	£ s. d.
1857	41,709 17 6	23,944 10 3	65,704 7 9
1858	38,731 9 0	68,333 18 9	107,065 7 9
1859	54,731 9 2	27,339 8 8	82,070 17 10
1860	41,603 13 4	38,507 9 8	80,111 3 0
1861	59,191 10 2	71,139 12 6	130,331 2 8
1862	140,558 7 7	103,846 0 0	244,404 7 7
1863	109,509 16 7	97,361 12 9	206,871 9 4
1864	42,589 1 7	85,633 0 11	128,222 2 6
1865	98,878 0 8	132,898 3 2	231,776 3 10
1866	24,415 7 3	73,246 5 9	97,661 13 0
1867	43,147 14 8	48,953 15 6	92,101 10 2
1868	100,232 7 11	84,911 16 5	185,144 4 4
1869	59,832 4 1	90,096 13 7	149,928 17 8
1870	108,890 8 1	31,122 13 6	140,013 1 7
1871	34,672 11 6	14,866 14 8	49,539 6 2
Total ...	998,693 19 1	992,251 16 1	1,990,945 15 2

Upon an abstract being made of 200 applications to the Company, amounting to 870,060*l.* 11*s.* 4*d.*, consisting of the two classes I and IV, in about equal proportions, where the estates have been charged with the outlay and attendant expenses, it appears that the percentage of the expenses which cover the Company's commission and the Inclosure Commissioners' charges, stamp duty, &c., was, on an average—

	£ s. d.
Where the landowner executed the work by his own agent ...	6 5 10
Where he employed the Company to execute it for him	7 12 5
The mean of the whole being	7 0 6

The number of cases in which landowners have charged their own money has been only six in number, and amount to 11,297*l.* 7*s.*

The number of landowners who have employed the Company to execute work for them without charging their estates at all are numerous, the greatest outlay in any one case being that made for the late Lord Palmerston.

12th May, 1873.

INDEX.

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LONDON :
HARRISON AND SONS, PRINTERS IN ORDINARY TO HER MAJESTY,
ST. MARTIN'S LANE.

[redacted]